FRONTIER HARD CHROME
SUPERFUND SITE
VANCOUVER, WASHINGTON

AMENDED RECORD OF DECISION

August 2001

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LIST OF ACRONYMS AND ABBREVIATIONS

ADI	Allowable Daily Intake
ARAR	Applicable or Relevant and Appropriate Requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Contaminant of Concern
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FHC	Frontier Hard Chrome
FS	Feasibility Study
gpm	gallons per minute
ISRM	In-Situ Redox Manipulation
MCL	Maximum Contaminant Level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MSL	Mean Sea Level
MTCA	Model Toxics Control Act
NAAQS	National Ambient Air Quality Standard
NCP	National Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
PCB	Polychlorinated Biphenyl
PCE	tetrachloroethene
POTW	Publicly Owned Treatment Works
ppb	parts per billion
ppm	parts per million
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RI	Remedial Investigation
ROD	Record of Decision

SARA	Superfund Amendments and Reauthorization Act
SWAPCA	Southwest Washington Air Pollution Control Authority
TBC	To Be Considered
TCLP	Toxicity Characteristic Leaching Procedure
TCA	trichloroethane
TCE	trichloroethene
USC	United States Code
VMC	Vancouver Municipal Code
VOC	Volatile Organic Compound
WAC	Washington Administrative Code
µg/kg	micrograms per kilogram
µg/L	micrograms per liter

PART 1: THE DECLARATION

SITE NAME AND LOCATION

Frontier Hard Chrome Superfund Site
Vancouver, Clark County, Washington
U.S. Environmental Protection Agency Identification Number WADO53614988

STATEMENT OF PURPOSE

This decision document presents the final remedial action selected by the U.S. Environmental Protection Agency (EPA) for soils and groundwater at the Frontier Hard Chrome Superfund Site, Vancouver, Clark County, Washington. This document, and the selected remedial action within, represents a fundamental change to the remedies selected in two previous Records of Decision, or RODs (1987 ROD for soils and a 1988 ROD for groundwater), and stands as an Amended Record of Decision to both previous RODs, addressing soils and groundwater.

The remedy in this Amended ROD was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the Administrative Record for this site.

The State of Washington Department of Ecology (Ecology) has participated in scoping the site investigations and in evaluating alternatives for remedial action. Ecology concurs with the selected remedy.

ASSESSMENT OF THE SITE

The response action selected in this Amended Record of Decision is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment. Such a release or threat or release may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDY

The soils at the Frontier Hard Chrome Superfund Site, and the groundwater beneath the site extending beyond the southern boundary of the Frontier Hard Chrome property, are contaminated with hexavalent chromium, which is highly mobile and toxic. The selected remedy will address the contamination through in-situ reduction of hexavalent chromium to

trivalent chromium, which is generally immobile and non-toxic. Reduction will occur through injection, or mixing, of reducing agents into contaminated soils and groundwater at the site.

The following are major components of the selected remedy:

- Contain Highly-Contaminated Groundwater: Containment of the most heavily contaminated groundwater at the site, or groundwater "hot spot" will involve the delivery, through injection or augering/injection, of reducing compounds on the down-gradient side of the soils source area, into the groundwater and soils. The compounds delivered to the area will reduce the naturally occurring iron, thereby creating an in-situ treatment barrier which reacts directly with the chromium in groundwater. As chromium-contaminated groundwater moving down-gradient passes through the permeable reactive zone, the hexavalent chromium in the groundwater is reduced to trivalent chromium, which is insoluble, and non-mobile. This In-Situ Redox Manipulation (ISRM) barrier will be in place prior to treatment of the soils source area and the groundwater plume "hot spot" in order to 1) provide containment of the groundwater "hot spot" as quickly as possible, 2) provide added protection during the in-situ treatment of the soils source area and the groundwater "hot spot" to prevent hexavalent chromium from moving down-gradient; and 3) provide long-term protection against future leaching of hexavalent chromium, should it occur. Reducing compounds will either be injected through a series of wells, or augered/injected into the groundwater. Recharge of the ISRM barrier is not anticipated because the soils source area up-gradient of the ISRM barrier will also be treated as described below. It is unlikely that residual concentrations of hexavalent chromium in the soils source area, should they exist after treatment, will pose a problem beyond the predicted life of the ISRM barrier.
- In-Situ Treatment of Source Area Soils and Groundwater "Hot Spot": In-situ treatment of the soils source area and the groundwater "hot spot" will involve the delivery of reducing compounds directly to site soils exceeding 19 mg/kg hexavalent chromium (soils source area) and contaminated groundwater with concentrations of hexavalent chromium exceeding 5,000 µg/L by augering/injecting or through injection wells. Augering/injection is the most likely method of delivery given the cost savings and the thorough mixing of reductant with soils the augering provides.[1]
- After treatment of soils exceeding 19 mg/kg and groundwater exceeding 5,000 µg/L, compaction of augered soils will be provided to allow for future use of the property to the extent practicable.
- Once the source area for soils (exceeding 19 mg/kg hexavalent chromium) and groundwater (exceeding 5,000 µg/L hexavalent chromium) have been treated, remaining groundwater exceeding the state groundwater cleanup standard of 50 µg/L (MTCA

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[1]Delivery of reducing compounds throughout the soils source area and the groundwater "hot spot" will more than likely require direct access to contaminated soils. Direct access will necessitate the demolition of both the Frontier Hard Chrome building and the adjacent Richardson Metal Works building.

Method A, total chromium) is expected to disperse and dilute. Regular monitoring of down-gradient groundwater to ensure dilution and dispersion of affected groundwater outside of the source area would be conducted until all remaining groundwater meets state standards for groundwater cleanup.

- Institutional controls and monitoring will be implemented to protect human health and the environment during the time required for dispersion and dilution to reduce chromium concentrations in plume areas outside of the "hot spot". In addition to the state and local institutional controls already in place, other institutional controls to be considered include placing notices and restrictions on property deeds that serve to prevent access to contaminated groundwater or future activities that threaten to remobilize chromium in site soils. Property owners would ensure that any future property transfers would include appropriate deed restrictions. Monitoring of existing wells will also be needed to track the concentrations in groundwater over time.

The implementation of the remedy will be phased with the installation of the ISRM treatment barrier being conducted in the first phase to contain the groundwater "hot spot". This remedy is selected because it addresses all source area soils and groundwater providing: 1) excellent overall protection of human health and the environment, 2) effectiveness long term, 3) permanence, 4) compliance with ARARs, 5) reduction in toxicity, and mobility, and 6) state acceptance, at a lower cost than other protective alternatives. The remedy will provide a permanent solution to ongoing threats posed by the Frontier Hard Chrome site to the groundwater and future threats posed to human health and the environment.

This remedy represents a fundamental change from the original remedies selected in the 1987 soils ROD, and the 1988 groundwater ROD. The1987 ROD called for removal, stabilization and replacement of 7400 cubic yards of soil - or all soils with concentrations greater than 550 mg/kg total chromium. The1988 ROD called for extraction of groundwater from the area of greatest contamination (levels of chromium in excess of 50,000 µg/L) via extraction wells, and treatment of extracted groundwater. Evaluation of these proposed remedies by EPA after the RODs were issued revealed the soils remedy to be ineffective. Groundwater monitoring conducted after the 1988 ROD was issued indicated that the contaminated groundwater plume was decreasing in size as down-gradient industrial supply wells were taken off line. Because new, cost-effective technologies were becoming available that provided the potential for more effective groundwater remediation, EPA reevaluated the need for pump-and-treat as the most appropriate solution for groundwater cleanup. The selected remedies for both the 1987 and 1988 RODs are retained in this Amended ROD for comparison purposes.

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate to the remedial action, is cost-effective, and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. This remedy also uses permanent solutions and satisfies the

statutory preference for treatment as a principal element (i.e., reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants as a principal element through treatment).

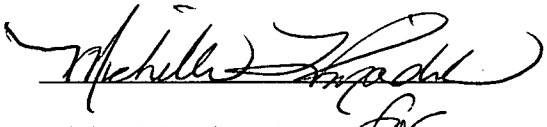
Because this remedy may result in hazardous substances, pollutants, or contaminants remaining at the site, a review will be conducted within five years after initiation of the remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this Amended ROD. Additional information can be found in the Administrative Record file for this site.

- Chemicals of concern and a summary of the concentrations found on site (Section 6, Nature and Extent of Contamination)
- Baseline risk represented by the chemicals of concern (Section 7, Summary of Site Risks)
- The Cleanup levels established for chemicals of concern and basis for the levels (Section 8, Remediation Objectives)
- The estimated capital and operation and maintenance costs, and the number of years over which the remedy cost estimates are projected (Section 10.2, Comparative Analysis of Alternatives, and Section 10.3, Summary of Comparative Analysis)
- Key factors that led to selecting the remedy. (Section 10.2, Comparative Analysis of Alternatives)
- A detailed description of the Selected Remedy (Section 11, Selected Remedy)

AUTHORIZING SIGNATURE



Michael Gearheard
Director, Environmental Cleanup Office

Date: 8/30/01

PART 2: DECISION SUMMARY

This Decision Summary provides a description of the site-specific factors and analyses that led to selection of the revised remedy for the Frontier Hard Chrome (FHC) Superfund Site. It includes information about the site background, the nature and extent of contamination, the assessment of human health and the environmental risks, and the identification and evaluation of remedial alternatives.

The Decision Summary also describes the involvement of the public throughout the process, along with the environmental programs and regulations that may relate to or affect the alternatives. The Decision Summary concludes with a description of the remedy selected in this Amended Record of Decision (ROD) and a discussion of how the selected remedy meets the requirements of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and to the extent practicable, the National Contingency Plan (NCP).

The Decision Summary is presented in the following sections:

Section 1	Site Name, Location, and Description
Section 2	Site History and Enforcement Actions
Section 3	Community Involvement
Section 4	Scope and Role of Operable Units
Section 5	Site Characteristics
Section 6	Nature and Extent of Contamination
Section 7	Summary of Site Risks
Section 8	Remediation Objectives
Section 9	Description of Alternatives
Section 10	Comparative Analysis of Alternatives
Section 11	Selected Remedy
Section 12	Statutory Determinations

The documents supporting this Decision Summary are included in the Administrative Record for the Frontier Hard Chrome Superfund Site.

1.0 SITE NAME, LOCATION, AND DESCRIPTION

The Frontier Hard Chrome (FHC) Superfund Site (the "site") is located in the southwestern part of the State of Washington, in the City of Vancouver, Washington. FHC is in an industrial area of the city directly across the Columbia River from the city of Portland, Oregon (see Figure 1). The area is generally flat, extending south, east, and west. About one quarter mile to the north, a ridge rises steeply to where a large residential area begins.

The site is approximately one-half mile north of the Columbia River and covers about one-half acre. The area is within a flood plain that has been extensively filled. There is a topographical depression about one and one-half acres in size adjacent to the east end of the site. The depression is generally five to twenty feet below the level of the site and represents a remnant of the old floodplain that has not been filled. The groundwater table is within twenty feet of the ground surface at the FHC site and is affected by the stage height of the river. The groundwater is used as the drinking water supply for the city of Vancouver, which has two well fields within one mile of the site.

2.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

2.1 Site History

In approximately 1955, the site was filled with hydraulic dredge material and construction rubble. Since then the site has been primarily occupied by two businesses, both engaged in the chrome plating business. Pioneer Plating operated at the site from 1958 to 1970. The site was then occupied by FHC until 1983. The property has been leased to various other businesses since 1983. Presently, the facility is being used as a metal shop.

During the operation of Pioneer and the initial operation of FHC, chromium plating wastes were discharged to the sanitary sewer system. In 1975, the City of Vancouver determined that chromium in the wastewater from FHC was upsetting the operation of its new secondary treatment system. FHC was directed by the city and the Washington State Department of Ecology (Ecology) to cease discharge to the sewer system until an appropriate wastewater treatment system could be installed to remove the chromium at the site.

In 1976, Ecology gave the FHC facility a wastewater disposal permit for discharge of chromium-contaminate wastewater to an on-site dry well. The permit also contained a schedule for the installation of an appropriate treatment system for the FHC wastewater stream. Between 1976 and 1981, several extensions of the permit and schedule were granted, as the deadlines were passed without compliance.

In 1982, Ecology found FHC in violation of the Washington State Dangerous Waste Act for the illegal disposal of hazardous wastes. Ecology also discovered that an industrial supply well about one quarter mile southwest of FHC was contaminated with chromium at more than twice the federal drinking water standard. FHC's wastewater permit was again modified with a new compliance date. FHC again did not comply with the permit requirements for economic reasons, and in December, 1982, the site was proposed for inclusion on the National Priorities List under CERCLA or Superfund. The listing was finalized in September, 1983.

In 1983, Ecology ordered FHC to stop discharge of chromium plating wastes to the dry well. FHC was also required to prepare a plan for the investigation of the groundwater. At that time, FHC closed down all operations at the site. The company did not undertake the investigation.

In March 1983, EPA and Ecology signed a Cooperative Agreement which gave Ecology the lead for investigation of the FHC site under Superfund. Ecology began the investigation in the fall of 1984. The Remedial Investigation (RI) led to a Feasibility Study (FS) to determine the cost-effective remedial action of the FHC site. The FS was completed in October, 1987.

EPA issued separate RODs for the soils/source control operable unit (December 1987) and the groundwater operable unit (July 1988). The December, 1987 ROD called for removal, stabilization and replacement of 7400 cubic yards of soil - or all soils with concentrations greater than 550 mg/kg total chromium (this number was based on a site specific leachate test for protection of groundwater). The July 1988 ROD called for extraction of groundwater from the area of greatest contamination (levels of chromium in excess of 50,000 µg/L) via extraction wells, and treatment of extracted groundwater. Evaluation of the soils remedy by EPA after the ROD was issued revealed that the chosen stabilization method was ineffective at preventing the leaching of hexavalent chromium from site soils. Groundwater monitoring conducted after the ROD was issued indicated that the contaminated groundwater plume was decreasing in size as down-gradient industrial supply wells located at FMC (Figure 1) were taken off line. Because new, cost-effective technologies were becoming available that provided the potential for more effective groundwater remediation, EPA reevaluated the need for pump-and-treat as the most appropriate solution for groundwater cleanup.

Based on surface soil sample analyses for total chromium conducted during the RI, Ecology completed a removal action in 1994 to reduce the threat of direct exposure and further impacts to groundwater from the most heavily contaminated surface soils. This action consisted of excavation of surface soil with chromium concentrations exceeding 210 mg/kg from the eastern most portion of the site (Figure 10). The area of excavation was subsequently backfilled with clean material and has been developed. Development consisted of construction of a commercial office building and adjacent parking.

In December, 2000, in conjunction with a drainage project on the adjacent Grand Avenue, the City of Vancouver extended a tight-lined drain pipe with road drains and catch basins up 1st Street (directly to the south of the FHC site) to the intersection with "Y" Street (directly to the west of the FHC site). The extension was engineered to handle all water flowing south on "Y" Street (which had previously entered the FHC site from 1st Street). The extension was provided in conjunction with an EPA Removal Action to provide drainage of surface water away from the FHC site, preventing further infiltration of surface water through contaminated soils on site.

Since the original RODs were issued, EPA has continued to monitor groundwater and soils, and evaluate new, innovative cleanup technologies to address the persistently high concentrations in soils and groundwater at the FHC site. In May, 2000, EPA finalized a Focused Feasibility Study (FS)which identified and evaluated several new and innovative technologies for addressing the problems at the site. One of the promising new in-situ treatment technologies identified in the Focused FS, In-Situ Redox Manipulation, or ISRM, was further evaluated in a bench scale test in February, 2001. The results of the bench scale test indicated that the technology would be appropriate for use at the FHC site.

In June 2001, EPA issued a Proposed Plan for cleanup of both soils and groundwater at the site. The Proposed Plan identified in-situ treatment using reducing compounds as EPA's Preferred Alternative. The public comment period for the Proposed Plan ended on July 25, 2001. EPA received one comment letter with two comments. These comments, and EPA's responses, are contained in a Responsiveness Summary which is included in Part III of this Amended ROD.

2.2 EPA Enforcement Activities

Frontier Hard Chrome, Inc. (FHC) ceased operations in 1983 and is no longer a viable entity. At its close, FHC had little in the way of assets. The owners of the property, who were also owners of FHC, Inc., did not receive any dividends or final distributions from FHC, Inc. As such, the regulatory and enforcement actions have centered on the owners of the site. Under Superfund, they are responsible parties and are liable for the site cleanup. Past negotiations between the responsible parties, EPA, and Ecology have not been productive. Since 1976, FHC has not complied fully with any agency orders. The site owners have not indicated any willingness or financial capability to undertake needed remedial actions at the site. Settlement negotiations with the owners are currently ongoing.

3.0 COMMUNITY INVOLVEMENT

Public interest at the site has generally been limited. There have been two public meetings for the purposes of informing the local population about the activities at the site and providing opportunities to comment. The initial meeting was held in October 1984 at the commencement of the RI/FS. The second meeting was held in November 1987, during the public comment period for the original soils Proposed Plan, to take formal public comment. Further information on the comments received during this public meeting can be found in the Responsiveness Summary for the original soils ROD.

Attendance at the meetings has been sparse. The meetings were attended by the responsible parties and by people directly associated with the operation of FHC. Adjacent property owners were also in attendance at the meetings. A transcript of the November 1987 public meeting was made, and a Responsiveness Summary was prepared. People who commented at the November 1987 meeting indicated that there was no need to take any action at all at the FHC site, with the exception of constructing an impermeable cap over the dry well area.

A second public notice and comment period took place in May and June 1988, to present information and receive comment on the Proposed Plan for groundwater cleanup. An opportunity for public hearing was given, however, no one from the public requested one. Three written comments were received on the Proposed Plan for groundwater cleanup. One comment indicated that the only remedial action needed is to construct a building over the highly contaminated area and to blacktop over the remainder of the site. Further information on these comments can be found in the Responsiveness Summary for the original groundwater ROD.

An additional public notice and comment period took place in June and July 2001, to present information and receive formal comment on the Proposed Plan for this Amended ROD, addressing both soils and groundwater. Again, an opportunity for a public hearing was given, however, no one from the public requested one. One comment letter was received with two comments. The commentor requested additional information concerning 1) the type and toxicity of potential by-products generated through the injection of sodium dithionite into contaminated site groundwater; and 2) the potential methods used for delivering reductants to the unsaturated vadose zone of contaminated soils. The commentor was generally supportive of EPA's Preferred Alternative for cleanup of soils and groundwater at the FHC site. For further information concerning these comments, and EPA's responses, refer to the Responsiveness Summary in Part III of this Amended ROD.

Periodic informational fact sheets have been issued to the public providing updates on site activities. Media interest in the site has generally been limited.

4.0 SCOPE AND ROLE OF OPERABLE UNITS

Historically, EPA has organized the work at the FHC site into two operable units (OUs):

- The soils OU; and
- The groundwater OU

This Amended Record of Decision selects final cleanup actions for both OUs at the site and serves to amend both previous RODs (the 1987 ROD for soils and the 1988 ROD for groundwater).

The soils OU includes surface and subsurface soils on the FHC site contaminated with hexavalent chromium which pose a threat to human health and the environment either through direct contact or impacts to groundwater. All active soil remediation alternatives evaluated in the Amended ROD focus on the soils source area, or that area defined by concentrations of hexavalent chromium in excess of 19 mg/kg as detailed in Figure 7. The soils source area covers approximately 28,000 square feet and extends to approximately 25 feet in depth for a total volume of 26,000 cubic yards. The soils source area is located on the FHC property, primarily below the former FHC facility, and the adjacent Richardson Metal Works property.

The groundwater OU includes groundwater contaminated with hexavalent chromium beneath the FHC property extending south beyond the property boundaries approximately 1000 feet. The OU's vertical extent includes the Alluvial aquifer from ground surface to approximately 35 feet in depth (the extent of the "A" zone). All of the active groundwater alternatives described in this Amended ROD address the specific portion of the plume with the highest concentrations, known as the plume "hot spot", while leaving larger areas of the plume with lower concentrations to dilute and disperse naturally in conjunction with continued monitoring and institutional controls. Based on groundwater monitoring data collected to date, EPA believes that the plume exceeding

state groundwater cleanup criteria which exists outside of the plume "hot spot" will dilute and disperse naturally if source area soils and groundwater ("hot spot") are effectively treated. The plume "hot spot" is defined as that area of the plume with concentrations of chromium exceeding 5,000 µg/L (Figure 8). This area roughly coincides with the contaminated soils source area, defined by soils concentrations in excess of 19 mg/kg (Figure 7). Beyond the "hot spot" remaining areas of the plume are characterized by lower concentrations ranging from 50 µg/L to 1,400 µg/L present over an area of approximately 500,000 square feet. Due to the high cost of potentially remediating this areas for limited contaminant removal, EPA will not be considering alternatives which address the entire plume.

5.0 SITE CHARACTERISTICS

5.1 Site Geology

5.1.1 General

The FHC site is located in the northern part of the Portland Basin, a sediment-filled structural basin located in northwestern Oregon and southwestern Washington. Older Eocene to Miocene volcanic and sedimentary rocks underlie the basin. The basin is filled with consolidated and unconsolidated non-marine sedimentary rocks containing important water-bearing units.

The FHC site is underlain by five geologic units. The youngest unit - the fill unit - consists of hydraulic fill and construction debris placed prior to development of the site. The fill unit was placed on fine-grained Holocene alluvium underlain by glacial flood deposits of the Pleistocene age. The Pleistocene flood deposits blanketed an ancient floodplain and several abandoned channels of the Columbia River, which were incised into the underlying Troutdale Formation. The sedimentary rocks of the Troutdale Formation in turn overlie a series of basalt flows that are part of the Columbia River basalt group. Approximately 1,600 feet of sediments overlie the Columbia River basalts in the vicinity of the FHC site.

5.1.2 Fill Unit

Before its development, the site was part of a gently undulating, swampy, alluvial floodplain terrace along the Columbia River. This surface has been modified by grading and the placement of up to 20 feet of fill for local industrial developments. Fill materials consist of both hydraulic fill (silt and sand) and construction fill. During the 1940s, hydraulic fill was used to level a swampy area between Pearson Air Park and Grove Street. The hydraulic fill materials consist of generally fine-grained sand, with silty sand near the surface and sand at depth. Construction fill was also placed at portions of the site beginning in the 1960s. The construction fill consists of concrete debris, asphaltic debris, red bricks, metal (iron chips), silt, sand, gravel, and minor quantities of clay. The construction debris fill is characteristically heterogeneous and poorly compacted. Approximately 12 to 20 feet of fill is present in the area of the FHC site. Figure 2 presents a conceptual model of the site hydrogeology.

5.1.3 Alluvial Unit

Underlying the fill unit is the alluvial unit, which consists of a thin, clayey silt subunit and a sand-and-ground subunit. The clayey silt unit displays a heterogeneous character ranging from silt to clayey silt to silty clay, with a variety of color ranging from reddish brown to dark bluish gray, and textures varying both laterally and vertically. Locally, the unit is rich with organic root fragments and displays shades of green to black. The unit typically appears massive in character; however, it is locally mottled and interbedded with a thin lamination of fine sand and silt. The unit is typically 3 to 7 feet thick, but thins to the north and is absent along the northern margin of the floodplain.

Underlying the clayey silt unit of the alluvial unit is the sand-and-ground unit. This subunit generally consists of poorly sorted sandy gravels, silty sandy gravels, and sandy silts. These sands and gravels are predominantly basaltic in composition with lesser amounts of quartz, metamorphics, and silicic volcanics. The fine-grained fraction consists primarily of brown to gray silt with minor amounts of clay. The sand and gravels are typically subrounded to rounded. Particle grain size ranges up to 8 inches in diameter; however, scattered larger cobbles are present.

In general, three lithofacies are present within this alluvial subunit: (1) poorly sorted deposits of silty sandy gravel to silty gravelly sand, (2) moderate to well-sorted deposits of coarse sandy gravel to gravelly sand, and (3) very dense deposits of sandy silt to silty sand. These three types of deposits display variation in particle size distribution and degree of sorting and, in general, are interbedded and discontinuous.

The deposits of silty sandy gravel to silty gravelly sand are interpreted to result from overbank deposition during major Columbia River flooding, when the river is carrying a large sediment load and little to no particle sorting occurs. These deposits are characterized by a high silt content, are generally dense, and appear well compacted.

The deposits of coarse sandy gravel to gravelly sand are interpreted to result from channel deposition that resulted in a higher degree of particle sorting than the associated overbank deposits. These deposits are characterized by a lower silt content and increased permeability.

In the general site area, a 1 to 5 foot-thick, semicontinous layer of very dense sandy silt to silty sand with lesser amounts of clay and gravel is present at approximately -3 to -7.5 (MSL). This layer is separate from, and lies below the clayey silt subunit which separates the fill unit from the Alluvial unit. This fine-grained unit was characterized by a high resistance to drilling and sampler penetration, with little to no groundwater inflow into boreholes during drilling. This fine-grained unit is important because the RI referred to this deposit as the "lower aquitard" separating the upper portion of the alluvial unit into the "A" and "B" zones. Although this layer may be a local semiconfining unit, the evidence suggests that this unit is not a significant hydraulic barrier within the alluvial aquifer.

5.2 Hydrogeology

Shallow groundwater in the FHC area occurs within a heterogeneous alluvial unit that is hydraulically connected to the Columbia River. In general, the alluvial unit exhibits both semiconfined and confined aquifer characteristics. This semiconfined condition is due, in part, to a low-permeability clayey silt subunit that directly overlies the alluvial aquifer and to permeability contrasts within the alluvial aquifer.

The site hydrogeology consists of (1)15 to 20 feet of fill and silty sand that is largely unsaturated (fill unit) , (2) a 3 to 7 foot-thick, upper, discontinuous layer of clayey silt, and (3) a heterogeneous anisotropic alluvial aquifer system that may be as thick as 70 feet beneath the site (Alluvial unit). Localized zones of perched groundwater are present within the fill materials above the top of the clayey silt. Figure 2 illustrates the general hydrostratigraphy inferred to be locally present in the FHC site area.

The uppermost hydrogeologic unit consists of perched groundwater in the fill unit. The fill unit is generally unsaturated, but locally perched water is present. The dry well used by FHC to discharge chromium-containing wastewater was open at the base of the fill unit. Groundwater in the perched aquifer is generally recharged from precipitation by direct infiltration and by stormwater dry wells and roof drains. Separating the fill unit from the alluvial unit is the 3 to 7 foot-thick, discontinuous, fine-grained unit.

Underlying the clayey silt unit is the alluvial aquifer. The alluvial aquifer is a sand-and-gravel layer beginning 15 to 20 feet below ground surface (bgs). The upper portion of the alluvial unit was subdivided in the RI into two water-bearing zones based on the presence of a discontinuous silty sand or sandy silt zone at a depth of 25 to 35 feet bgs. The upper zone has been referred to as the "A" zone or "A" aquifer, and the lower zone has been designated as the "B" zone or "B" aquifer. The silt zone, when present, varies from 1 to 3 feet in thickness and appears to be discontinuous. The silt zone was recognized by an increase in drilling resistance and little or no groundwater entering the drill casing as the boring encountered this unit. Although this layer may be a local semiconfining unit, the evidence suggest this unit is not a significant hydraulic barrier within the alluvial aquifer.

The groundwater potentiometric surface generally slopes very shallowly to the south in the vicinity of the FHC sit. Recharge to the alluvial aquifer system occurs north of the site along the northern margin of the floodplain from another hydraulically connected alluvial aquifer. In addition, recharge also occurs from direct infiltration of precipitation. Groundwater discharges to the Columbia River. Seasonal fluctuations in the river stage exert a strong influence on water levels and the hydraulic gradients within the alluvial aquifer system.

Representative water levels in the "A" and "B" zone wells are presented in Figures 3 and 4 respectively. Groundwater flow is approximately 0.5 to 5 feet per day toward the river. The hydraulic gradient averages 0.00015 ft/ft. The alluvial aquifer is hydraulically connected to the Columbia River, and the groundwater levels in the alluvial aquifer appear to be controlled

primarily by the stage of the Columbia River. During high river stages, groundwater flow away from the river has been recorded. There is no distinct vertical gradient between the "A" and "B" wells.

The hydraulic conductivity of the alluvial aquifer ranges from 1 X 10^{-3} to 1 X 10^{-1} cm/sec and averages 5 X 10^{-1} cm/sec, as measured by slug tests, grain size analysis, and pumping tests.

6.0 NATURE AND EXTENT OF CONTAMINATION

6.1 General

Hexavalent Chromium is the contaminant of primary concern at the FHC site. While volatile organic compounds (VOCs), including tetrachloroethene (PCE) and trichloroethene (TCE) have been detected in groundwater at the site, concentrations have been extremely low and are not directly linked to past activities at FHC. Nickel and lead were also found in soils at the facility during the RI. The contaminant levels of these substances were much less than those for chromium. Though the levels of exposure were not zero, the additional risk imposed was negligible.

Releases from FHC operations contaminated groundwater with reported chromium concentrations as high as 300,000 µg/L. At the time the contamination was first detected in 1982, a groundwater plume exceeding federal drinking water standards (50 µg/L) extended approximately 1600 ft southwest from the facility (Figure 5). Groundwater monitoring since initial discovery has shown that the plume has receded. Monitoring in 2000 indicated that the plume exceeding state groundwater cleanup standards extends approximately 1000 feet south of the site (Figure 6). The change in overall plume size, and the shift in groundwater flow from the site in a southwesterly direction to a more southerly direction is largely due to the discontinued pumping of three large industrial supply wells located at the FMC (Figure 1) facility. With the influence of these wells eliminated, the plume is conforming to natural groundwater flow. While monitoring indicates that the plume is receding, it also shows that concentrations beneath the FHC site, or the plume "hot spot"area, defined in this plan by chromium concentrations exceeding 5,000 µg/L, have remained consistently high over time.

Concentrations of total chromium[2] in surface soils collected for the RI were found as high as 5,200 mg/kg while recent surface soil samples (Weston 1999) revealed concentrations of hexavalent chromium[3] near the FHC building as high as 42 mg/kg. Subsurface concentrations for total and hexavalent chromium have been noted as high as 31,800 mg/kg and 7,506 mg/kg respectively. Contaminated subsurface soils extend beneath the neighboring Richardson Metal Works building. All active soil remediation alternatives discussed below focus on the soils source area, or that area defined by the Remedial Action Objectives (below) as having concentrations of hexavalent chromium in excess of 19 mg/kg (Figure 7). The soils source area covers approximately 28,000 square feet and extends to approximately 25 feet in depth for a total volume of 26,000 cubic yards.

6.2 Groundwater

6.2.1 Wells on the FHC Property and Adjacent Richardon Metals and Cassidy Manufacturing Properties.

Groundwater samples have been collected from 40 monitoring wells installed within the FHC study area which includes the FHC property and the adjacent Richardson Metals and Cassidy Manufacturing properties.. These samples have been analyzed for metals, VOCs, pesticides, polychlorinated biphenyls (PCBs), and conventional water quality parameters. The results of the groundwater sampling for metals and VOCs are presented in Appendix A of the Final Focused Feasability Study (URSG, 2000), located in the AR for this Amended ROD. In addition, groundwater samples have been collected from 30 push probe locations at the site ("A" zone and perched zone) using direct-push sampling methods (URSG 1999).

Four groundwater sampling events were conducted during the 1985-86 RI; eight groundwater sampling events were conducted during the 1990s, and one in 2000. The initial results of the RI

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[2]Total chrome results show concentrations of all forms of chromium including trivalent and hexavalent. Total chromium results for groundwater sampling typically reflect the concentrations of the more toxic and highly mobile form - hexavalent chromium. 1997 groundwater sampling results comparing hexavalent chromium concentrations to total chromium concentrations show that the hexavalent chromium concentrations average 97 percent of the total chromium concentrations. These results indicate that there is little significant difference between the hxavalent and total chromium values and that essentially all of the chromium present in groundwater is in the hexavalent form. This is not unexpected because the other form of chromium, trivalent, is only very slightly soluble in typical groundwater pH conditions. The pH in groundwater samples collected during the August 1999 investigation ranged from 5.7 to 7.3 and averaged 6.6, which is in the typical range of groundwater pH.

[3]Hexavalent chromium results indicate only the concentrations for hexavalent chromium. Hexavalent chromium is highly mobile and toxic, typically migrating from soils to groundwater as surface water flows down through the soil.

showed that groundwater beneath the site contains significant concentrations of total and hexavalent chromium concentrations and that the chromium had spread beyond the boundaries of the FHC property to the southwest. One round of groundwater sampling was conducted in July 1992 as part of Remedial Design studies. Groundwater samples were collected by ICF Technology on October 1992; January, April, and October 1993; and May 1994. Weston collected water samples in the spring of 1997 and 1999. The spatial distribution of hexavalent total chromium in perched and "A" zone groundwater from the 1999 direct-push sampling is shown in Figures 8 and 9 respectively. URS Greiner collected groundwater monitoring samples in the winter of 2000.

The reduction of chromium concentrations in some areas of the site suggests that dispersion and dilution of chromium is occurring in plume areas down-gradient of the source, while plume concentrations in the source area have remained consistently high. For instance, total chromium in "A" zone groundwater from a push-probe sampling location beneath the former FHC building in the source area was approximately 119 mg/L in August 1999.

6.2.2 Additional Wells

Water samples were collected from several locations beyond the boundaries of the FHC, Richardson Metals, and Cassidy Manufacturing properties, including monitoring wells, irrigation wells, public water supply wells, and local drinking water sources. Water samples were collected from the monitoring wells located at the Cascade Tempering property; the irrigation well at the Washington School for the Deaf track; drinking water sources in the vicinity of FHC, and the Fort Vancouver National Historic Site.

Total and hexavalent chromium concentrations were not detected in the potable water samples except for dissolved chromium in one sample (drinking water fountain at the Richardson Metal Works building). Chromium was not detected when this source was resampled.

Based on comparison of total chromium concentrations from groundwater sampling in 1987 and 1999, a significant reduction in chromium concentrations beyond the southern boundary of the FHC site is evident. The extent of chromium appears to have been significantly reduced in this area, most likely due to dilution and dispersion. The hexavalent chromium plume was likely drawn beyond the sourthern boundary of the FHC property to the southwest by industrial supply wells that operated prior to 1983 at FMC. In the period since these wells ceased pumping, the natural gradient and direction of the groundwater flow has been reestablished, resulting in dilution and dispersion of the plume down-gradient of the source area.

6.2.3 1999 Push Probe Sampling

In addition to groundwater samples collected from 1985 through 2000 from monitoring wells installed for site investigation, groundwater samples were collected and tested for chemicals of interest during a push-probe investigation of the site in August 1999 (URSG 1999). Samples from the "A" zone aquifer and perched zone were tested in a treatability evaluation of In-Situ

Redox Manipulation, or ISRM (PNL 1999). Groundwater samples were collected from the "A" zone aquifer at 30 push-probe sample locations. Based on low concentrations of chromium in "B" zone aquifer groundwater samples, this investigation did not include testing or investigation below the "A" zone at the site. Perched groundwater samples were collected from 17 of the 30 push-probe locations.

Dissolved chromium was detected in 18 of 30 "A" zone samples and 15 of the 17 perched zoned samples. Detected chromium concentrations in the "A" zone groundwater samples ranged from 6.8 to 119,00 µg/L. The highest concentrations were detected at sampling locations GP-06, GP-12, and GP-26, all located inside and immediately southeast of the former FHC building. The detections of chromium in "A" zone groundwater are shown in Figure 8.

Detected chromium concentrations in perched zoned groundwater samples ranged from 5.7 to 48,700 µg/L. The highest concentrations were detected at sampling locations GP-06 and GP-12, located immediately southeast of the former FHC building. The distribution of chromium in perched groundwater is shown in Figure 9.

6.3 Surface Water

Three surface water samples were collected during the RI from surface water puddles on the FHC property. Total chromium was detected in all surface samples at concentrations ranging from 0.01 to 0.9 mg/L. While chromium was detected, human health risk from exposure to the surface water was considered minimal. Any remedial action implemented would likely reduce the contamination of the surface water on the site, further reducing any risk from this exposure. Risk due to contamination of the Columbia River was modeled and found to be negligible due to the low concentrations of chromium detected in groundwater near the river, and predicted dilution of groundwater as it migrates to and enters the river.

6.4 Surface Soil

Surface soil samples were collected from 89 locations as part of the RI (Figure 10). Total chromium was found in concentrations from less than 2 mg/kg to 5,200 mg/kg. Three samples were analyzed for hexavalent chromium, and the results ranged from less than 0.5 mg/kg to 10 mg/kg. The highest surface soil concentrations were near the dry well. However, an area directly north of the FHC building and another area at the east edge of the site also had elevated levels of total chromium (Figure 10).

Seven surface soil samples were analyzed using the EPA Toxicity procedure for waste disposal characterization. The seven samples had a range of 25 to 5,200 mg/kg of total chromium, but only the sample with 5,200 mg/kg chromium yielded an EP toxicity extract concentration above the detection limit, with a concentration of 0.2 mg/L.

Based on surface soil sample analyses for total chromium, Ecology completed a removal action in 1994 to reduce the threat of direct exposure and further impacts to groundwater from the most

heavily contaminated surface soils. This action consisted of excavation of surface soil with chromium concentrations exceeding 210 mg/kg from the eastern most portion of the site (Figure 10). The area of excavation was subsequently backfilled with clean material and has been developed. Development consisted of construction of a commercial office building and adjacent parking. The area of surface contamination that was not addressed during this removal action is primarly adjacent to the former FHC building and the Richardson Metals building. Based on the RI investigation, some hotspots existed to the north of the former FHC building. However, in the intervening period since the RI was completed, natural and anthropogenic activities have resulted in a redistribution of chromium-impacted surface soil.

6.5 Subsurface Soil

Subsurface soil samples were collected from the site as part of RI (Dames and Moore 1987) and RD studies (Radian 1991; ICF Technology 1993). Total chromium concentrations in subsurface soils ranged up to 31,800 mg/kg. The depth of the most contaminated soils ranged to 20 feet below grade. Generally, the maximum chromium concentrations in soil borings were at the fill/clay interface that is present at depths of 15 to 20 feet across the site.

Hexavalent chromium concentrations in subsurface soil obtained during investigation activities in 1999 (Weston) are shown in Figures 11 and 12. Hexavalent chromium concentrations ranged from less than detection limit to 7,506 mg/kg. The maximum hexavalent chromium concentration in the 1999 investigation was from a push-probe sample collected beneath the FHC building, in the source area (soils exceeding 19 mg/kg hexavalent chromium - see Figure 7).

6.6 Current and Potential Future Site and Resource Uses

6.6.1 Land Uses

Land use in the FHC area is primarily industrial, with some manufacturing and commercial uses. Land ownership in the area is predominantly private, with the exception of Pearson Air Park, which is publicly owned. The site and surrounding properties are zoned "ML" by the City of Vancouver, allowing light industrial use. While residential development south of the site along the Columbia river is occurring, projected land use at the site and in the immediate vicinity is expected to remain light industrial.

6.6.2 Ground Water Uses

At present there are no active wells in the contaminated aquifer, and a number of state and local institutional controls are in place which prevent utilization of the contaminated groundwater plume. The City of Vancouver has several municipal codes that regulate water hookups within the city limits. Pursuant to Vancouver Municipal Code (VMC) 14.04, the public works director has established a Utility Review Process which requires that new developments demonstrate how they will connect to the public water supply system. Building permits are not issued without an

approved utility review. Policy P86 of the City of Vancouver's Growth Management Plan states that "new private wells are not permitted within the Vancouver urban area." Policy P87 states that "existing and private wells should be properly abandoned in accordance with state regulations and converted to public water service when it becomes available." State regulation WAC 173-160-055 requires that all well drillers notify Ecology 72 hours in advance of the intent to construct, reconstruct, or abandon a well. Additionally, the Health District has regulations regarding new developments, requirements for drinking water sampling and permits required for new construction within city limits. The groundwater in the greater area generally is used for drinking water but existing drinking water wells are not currently affected by chromium-contaminated plume, nor is it expected that they will be in the future.

Water supplies currently used in the area include two City of Vancouver municipal supply wells approximately on mile from the site and an irrigation well located about 1000 feet to the east. These wells were sampled found not to be affected by the site. Groundwater modeling done in the FS indicates very little chance of the contamination spreading to these existing wells, as they are not in line with the direction of the contaminated plume. However, any future well development within or near the existing plume of contaminated groundwater, in spite of city and local institutional controls, would pose significant risks to future users.

6.7 Principal Threat Waste

The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable (NCP Section 300.430(a)(1)(iii)(A)). Principal threat wastes include wastes with high concentrations of toxic compounds or wastes that are highly mobile which generally cannot be contained in a reliable manner or that would present a significant risk to human health and the environment should exposure occur.

Hexavalent chromium is the principal threat waste at the FHC site in soils and groundwater. Hexavalent chromium remains in site soils and groundwater at very high concentrations and is highly mobile and toxic. There are currently no controls in place to prevent hexavalent chromium in soils from impacting groundwater, or to prevent contaminated groundwater from migrating further down-gradient.

The Selected Remedy described below in Section 10 utilizes in-situ treatment to reduce hexavalent chromium in soils and groundwater to trivalent chromium, which is essentially immobile and nontoxic. The technology will provide a permanent solution to the hexavalent chromium contamination in soils and groundwater at the FHC site.

7.0 SUMMARY OF SITE RISKS

7.1 General

Chromium is the hazardous substance of primary concern at the FHC site. Chromium is present in two forms, designated trivalent chromium and hexavalent chromium. Of the two, hexavalent chromium is the more hazardous. EPA classifies hexavalent chromium as a Group A carcinogen (evidence of human carcinogenicity) when inhaled. The level of allowable chromium in the air is 25 micrograms per cubic meter based upon an occupational exposure of eight hours per day. For protection of public health, the federal drinking water standard (Maximum Contaminant Level, or MCL) for total chromium is set at 100 µg/L.

The risk from exposure to chromium from direct contact and inhalation of dust was investigated in 1987 and long term exposure was modeled based on surface soil contaminant concentrations. Exposure was measured using personal air monitoring samples obtained from on site workers. Long term exposure was modeled based on surface soil contaminant concentrations. It was determined that the levels of exposure were well below the amount allowed in standards for occupational settings. According to the Assessment, chromium does not exceed the 10^{-7} cancer risk for long term airborne exposures. These exposure estimates do not account for potentially higher short term exposures to dust due to vehicular traffic and wind. This increased risk was not quantified.

The greatest risk presented by the FHC site is through contamination of the groundwater and the drinking water supply with hexavalent chromium. The aquifer is contaminated in excess of federal drinking water standards (MCL). At present there are no active wells in the contaminated groundwater plume and a number of state and local institutional controls are in place which prevent the utilization of the contaminated groundwater.

Based on all of the available data, currently there does not appear to be any contaminated groundwater exceeding Washington State chronic surface water criteria for chromium for protection of freshwater aquatic life - 10.5 µg/L seeping into the Columbia River from the FHC groundwater plume. The concentrations of chromium in the groundwater immediately adjacent to the Columbia River were predicted using a groundwater flow simulation model. With no groundwater cleanup, the level of chromium at receptors along the river was predicted to rarely exceed the State standard for chromic surface water for chromium at 10.5 µg/L. This is due to dilution of the contaminate plume which occurs as groundwater migrates to and enters the river.

Likelihood of exposure to human health and the environment from contaminated soils and groundwater at the FHC site over the next several years is low given the current size and direction of the plume, and chromium concentrations in surface soils. The site does, however, present an ongoing threat to groundwater, and potentially to human health and the environment in the future if left uncontrolled.

7.2 Endangerment Assessment, Summary

An Endangerment Assessment was conducted as part of the original Feasibility Study to evaluate the risk to public health posed by the site and to assist in determining the proper level of remedial response (Dames and Moore and Bovay Northwest 1987). Although the groundwater contaminant concentrations have changed since the 1987 report was written, recent data suggest that the same types of risk are still present. The magnitude of site risks has decreased over time, but groundwater still exceeds maximum contaminant levels (MCLs), and soil exceeds human health cleanup criteria. Based on these conditions, a revised risk assessment was not completed for this Amended ROD because the conclusions of the 1987 assessment are still valid.

Six hazardous substances were identified in the RI to be present in one or more media at concentrations of potential concern to human health and the environment. All were considered in the 1987 Endangerment Assessment. These substances are: chromium, nickel, lead, PCE, TCE, and TCA. During the 1999 groundwater investigation activities, PCE and TCE were detected in 23 and 24 of 30 "A" zone groundwater samples. Only three PCE concentrations exceeded the MCL (5 µg/L) and only one TCE concentration exceeded the MCL standard. VOCs are not being considered further for remedial actions because 1) concentrations have been extremely low and few detections have exceeded the respective MCL criteria, 2) VOCs in groundwater have historically been an area-wide problem, not specific to FHC, and 3) the presence of VOCs is not directly linked to past activities at FHC. Nickel and lead were also found in soils at the facility during the RI. The contaminant levels of these substances were much less than those for chromium. Nickel at the site did not exceed the 10^{-7} cancer risk for long-term airborne exposures. Lead also presented minimal risk at the site in that the levels did not exceed and were not expected to exceed the National Ambient Air Quality Standards. Though the levels of exposure were not zero, the additional risk imposed by the dust was negligible. A review of the toxicological properties of these chemicals is contained in the Endangerment Assessment which is contained in the Administrative Record for the FHC site.

Hexavalent chromium is the hazardous substance of primary concern at the FHC site. Hexavalent chromium is a potential carcinogen when inhaled, is highly mobile in groundwater, and is toxic at low concentrations. The level of allowable chromium in the air is 25 micrograms per cubic meter based upon an occupational exposure of eight hours per day.

The risk from exposure to chromium from direct contact and inhalation of airborne dust was investigated as part of the Endangerment Assessment. Exposure was measured using personal air monitoring samples obtained from on site workers. Long term exposure was modeled based on surface soil contaminant concentrations. It was determined that the levels of exposure were well below the amount allowed in standards for occupational settings. According to the Assessment, chromium does not exceed the 10^{-7} cancer risk for long term airborne exposures. These exposure estimates do not account for potentially higher short term exposures to dust due to vehicular traffic and wind. This increased risk was not quantified.

Surface water was also examined near the site. Standing water in puddles were sampled for the presence of chromium. Chromium was found but human health risk from exposure to the surface water was considered minimal. Any remedial action implemented would likely reduce the contamination of the surface water on the site, further reducing any risk from this exposure. Risk due to contamination of the Columbia River was modeled and found to be negligible due to the low concentrations of chromium detected in groundwater near the river, and predicted dilution of groundwater as it migrates to and enters the river.

The greatest risk presented by the site is through the contamination of the groundwater and the drinking water supply with hexavalent chromium. Transport of groundwater contaminants off site was evaluated for hexavalent chromium. Target population receptors were evaluated for exposure at downgradient well locations, the nearest municipal supply well, and a school irrigation well. A groundwater contaminant transport model was used to predict exposure via the groundwater pathway.

Hexavalent chromium concentrations in impounded surface waters, site runoff, and groundwater discharge to the Columbia River were also evaluated either by direct observations or model predictions. Target populations were those that might come in contact with these waters during recreational, occupational, or incidental activities. Surface water exposure estimates were developed using limited field data. Groundwater exposure estimates were based on the same predictive model used to evaluated the potable groundwater pathway.

7.2.1 Endangerment Assessment Findings

Groundwater Pathway: The modeling results for a 70-year scenario suggest little impact at existing domestic or municipal water wells. The maximum predicted probability of exceeding the MCL for chromium was 5%.

However, a hypothetical well within and near the existing groundwater plume would be severely impacted. Hexavalent chromium levels as high as 714,000 µg/L were predicted for these wells, as compared to the MCL. Groundwater concentrations of total chromium as high as 300,000 µg/L (1985) have been detected in the contaminated plume.

Groundwater discharges to the Columbia River: The concentrations of chromium in the groundwater immediately adjacent to the Columbia River were predicted using a groundwater flow simulation model. With no groundwater cleanup, the level of chromium at receptors along the river was predicted to rarely exceed the State standard for chromic surface water for chromium at 10.5 µg/L. This is due to dilution of the contaminate plume which occurs as groundwater migrates to and enters the river.

Airborne Pathway: All airborne exposure analyses were based on predicted annual averages and assumed total chromium to hexavalent chromium ratios. Hexavalent chromium values for surface soil samples were unavailable, so were instead estimated using chromium to hexavalent chromium ratios from subsurface borings. The error inherent in the use of the observed

chromium to hexavalent chromium ratios was incorporated in the analysis, and this error is reflected in the estimated probabilities of exceeding standards and the 95th percentile risk estimates. The 95th percentile excess cancer risk for chromium did not exceed the 10^{-7} level on site or the 10^{-8} level off site.

Surface Water Pathway: Due to the limited amount of surface water at the site during characterization, insufficient data were available to conduct a detailed assessment of the human health and environmental risk due to surface water transport.

Incidental Ingestion Pathway: Worst-case scenarios for chromium ingestion of on-site soils or acute consumption of blackberries grown on site exceed allowable daily intake (ADI) values for chromium for children. However, in both of these cases, other exposures - notably inhaled dusts - might be of greater concern to children accessing the site. Analyses of on-site ingestion scenarios for children assumed residential use of the site.

7.3 Conclusions

Observed groundwater monitoring results for chromium show levels that present a substantial and imminent endangerment to the public if drinking water resources were developed in the area of the existing and predicted plume to the south of the site.

The aquifer is contaminated in excess of the MCL. The groundwater in the greater area generally is used for drinking water but existing drinking water wells are not currently affected by chromium-contaminated plume, nor is it expected that they will be in the future. However, any future well development within or near the existing plume of contaminated groundwater would be severely impacted. The risk from drinking contaminated water is based on the potential use of the water from the contaminated portion of the aquifer. This threat to the potential drinking water supply is expected to remain if no actions are taken to remedy the site.

The site presents an ongoing threat to groundwater, and potentially to human health and the environment in the future if left uncontrolled. These risks include the following:

- A groundwater plume with concentrations exceeding the MCL currently extends 1000 feet south of the FHC site and there are currently no controls to restrict the movement of this plume, or continued impacts to groundwater from highly contaminated soils. This uncontrolled plume presents an existing and future threat to the groundwater as a resource to the City of Vancouver.
- As described above, although the FHC plume appears to be shrinking, posing no immediate threat to the Columbia River and existing drinking water wells, concentrations at the center of the plume have remained consistently high since the site was discovered. Concentrations in soils on site have also remained consistently high, and continue to act as an ongoing source of contamination to the aquifer.
- Future use of the FHC site may include demolition of on-site structures. The highest concentrations of chromium in soil and groundwater exist below these structures.

Potential removal of these structures without proper oversight from appropriate agencies presents two major risks: 1) risk to workers, on site personnel and the community from direct contact with heavily contaminated soil and inhalation of contaminated dust particles, and 2) flow of surface water through heavily contaminated soils previously covered with on-site buildings, causing hexavalent chromium in these soils to leach more readily into groundwater.

- Future use of the FHC site may not be restricted to industrial use. The area north of the Columbia River where FHC is located is undergoing rapid residential development. While FHC and the immediate environs are currently light industrial, this designation may change as the demand for further residential development increases. Current exposure scenarios for airborne dust emissions assume that FHC is an industrial site with an 8 hour work day. Incidental ingestion of contaminated surface soils as a risk factor has never been thoroughly evaluated given the industrial nature of the site and the concentrations present. If future use of the site becomes residential, exposure scenarios will change, and current levels of contamination in surface soils may be unsafe.

While current risks to human health and the environment are low, EPA believes that the current and future impacts to the groundwater, as well as potential future risks posed by contaminated soils and groundwater at the FHC site, warrant active cleanup. The response action selected in this Amended Record of Decision is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment. Such a release or threat or release may present an imminent and substantial endangerment to public health, welfare, or the environment.

8.0 REMEDIATION OBJECTIVES

8.1 Remedial Action Objectives

Remedial Action Objectives (RAOs) are specific goals to protect human health and environment. Generally, RAOs identify the exposure routes, receptors, chemicals of concern, and a human health or environmental cleanup objective.

EPA has established the following RAOs for contaminated groundwater at the site:

Restore all hexavalent chromium-contaminated groundwater to groundwater cleanup standards (MTCA A standards)

Prevent ingestion of hexavalent chromium-contaminated groundwater above state groundwater cleanup standards (MTCA A standards)

Prevent chromium-contaminated groundwater from seeping into the Columbia River above chronic state standards for the protection of fresh water aquatic organisms

EPA has established the following RAOs for contaminated soils at the site:

Prevent hexavalent chromium in soils from serving as an uncontrolled, ongoing source of contamination to groundwater

Prevent current and future exposure to soil contaminated with chromium above state standards for unrestricted future use

Summary of Cleanup Levels

Media	Chemicals of Concern	Cleanup Levels	Source of Cleanup Level
Groundwater	Total Chromium	50 µg/L 10.5 µg/L	MTCA A State Chronic Surface Water
Soil	Hexavalent Chromium Hexavalent Chromium Trivalent Chromium	19 mg/kg 400 mg/kg 80,000 mg/kg	MTCA A MTCA B MTCA B

MTCA A = "Model Toxics Control Act, Method A" is set by the Washington State of Department of Ecology. Values are set for unrestricted future use. A value of 100 µg/L may be used if the chromium in groundwater is trivalent chromium. MTCA A for hexavalent chromium in soils is established for the protection of groundwater. Values are set for unrestricted future use

MTCA B for hexavalent chromium in soils is established for human health protection through direct contact. The value of 400 mg/kg is determined not to be protective of groundwater at the site. Therefore, the MTCA A hexavalent chromium value of 19 mg/kg will serve as the cleanup level for cleanup.

MTCA B for trivalent chromium is established for human health protection through direct contact. EPA will demonstrate that this value is also protective of groundwater through historical data evaluation, modeling, and/or future monitoring (see Section 10 below for further discussion).

8.2 Key Applicable or Relevant and Appropriate Requirements

The key Applicable or Relevant and Appropriate Requirements (ARARs) for cleanup of groundwater at the FHC site include the State of Washington Model Toxics Control Act (MTCA), Method A groundwater cleanup standards, and the State of Washington chronic surface water criteria. For soils, the key ARARs include the MTCA Method A cleanup standard for unrestricted future use for hexavalent chromium, and the MTCA Method B standards for protection of human health through direct contact for trivalent chromium.

For hexavalent chromium in soils, the MTCA Method A standard for unrestricted future use and protection of groundwater (19 mg/kg) is appropriate for the FHC site. Although the MTCA Method B direct contact standard of 400 mg/kg is appropriate for the protection of human health through direct contact, it is inappropriate for the protection of groundwater.

Conversely, EPA believes that the MTCA Method B standard for trivalent chromium of 80,000 mg/kg in soils for protection of human health through direct contact is appropriate for the FHC site, including the protection of groundwater. According to the requirements of WAC 173-340-747, EPA will demonstrate that the MTCA Method B direct contact standard is also protective of groundwater through modeling, historical data evaluation and/or future monitoring.

As the Selected Alternative in this Amended ROD utilizes the injection of reductants into the groundwater, it must comply with WAC 173-218 - the Underground Injection Control Program - which sets forth procedures and practices applicable to the injection of fluids through wells.

9.0 DESCRIPTION OF ALTERNATIVES

The list of cleanup alternatives for soil and groundwater described and evaluated below is drawn from the May, 2000 Final Focused Feasibility Study, but includes the selected alternatives from the 1987 and 1988 RODs for comparison. Alternatives evaluated in the 1987 ROD for soils which are not carried forward for discussion in this Amended ROD include: excavation/treatment/off-site disposal, due to cost; and biological treatment, due to technical infeasibility. While this Amended ROD does evaluate extraction and treatment of groundwater from the plume "hot spot", it does not evaluate extraction and treatment of all groundwater contaminated above state groundwater cleanup standards as included in the 1988 ROD. Extraction and treatment of all groundwater contaminated above state groundwater cleanup standards is not evaluated in this Amended ROD because the costs would be excessive for marginal gain in contaminant removal.

Alternative description and evaluation is divided into separate discussions of "groundwater" and "soil" remedies for ease and clarity of presentation. Combinations of groundwater and soil remedies are briefly discussed in the "Comparative Analysis of Alternatives" section below, and more specifically in the "Selected Remedy" section.

9.1 Groundwater

All of the active groundwater alternatives described in this Amended ROD address the specific portion of the plume with the highest concentrations, known as the plume "hot spot", while leaving larger areas of the plume with lower concentrations to dilute and disperse naturally in conjunction with continued monitoring and institutional controls. Based on groundwater monitoring data collected to date, EPA believes that the plume exceeding state groundwater cleanup criteria which exists outside of the plume "hot spot" will dilute and disperse naturally if source area soils and groundwater ("hot spot") are effectively treated. The plume "hot spot" is defined as that area of the plume with concentrations of chromium exceeding 5,000 µg/L (Figure 8). This area roughly coincides with the contaminated soils source area, defined by soils concentrations in excess of 19 mg/kg (Figure 7). Beyond the "hot spot" remaining areas of the plume are characterized by lower concentrations ranging from 50 µg/L to 1,400 µg/L present over an area of approximately 500,000 square feet. Due to the high cost of potentially remediating this areas for limited contaminant removal, EPA will not be considering alternatives which address the entire plume.

Alternative 1 - No Further Action: CERCLA requires evaluation of a no-action alternative to reflect future conditions without any cleanup effort. This alternative is used for comparison to other alternatives and does not include any type of institutional controls.

Under this alternative no additional actions would be taken to cleanup soils or groundwater at the FHC Site. No controls would be imposed to prevent installation of drinking water wells on the site or in the area surrounding the site where impacted groundwater has migrated. No measures would be taken to prevent migration of contaminants into the Columbia River. No warnings would be posted on the site identifying the potential hazards associated with consumption or prolonged contact with the groundwater.

Alternative 2 - Institutional Controls/Monitoring: This alternative consists of allowing the chromium in the groundwater to disperse and dilute with time under no outside influence. Institutional controls and monitoring would also be implemented to protect human health and the environment during the time required for dispersion and dilution to reduce chromium concentrations. In addition to the state and local institutional controls already in place, institutional controls would consist of placing notices and restrictions on property deeds. The notices would inform new buyers and existing occupants of surrounding businesses of the impacted groundwater and its potential adverse effects on human health if groundwater were consumed. Property owners would ensure that any future property transfers would include deed restrictions that would prevent the installation of drinking water wells on the impacted properties. Monitoring of existing wells would be needed to track the concentrations in groundwater over time. In the event contaminant concentrations increased in surrounding wells that previously had no detections above acceptable levels, owners of properties and known users of wells would be warned, and additional deed restrictions and health advisories would be issued. Deed restrictions and notices would be removed when concentrations in the wells

decreased to acceptable levels. Monitoring would be required until groundwater meets state MTCA A groundwater cleanup standards.

Alternative 3 – Pump and Treat/Institutional Controls/Monitoring (Selected alternative in 1988 ROD): This alternative would involve the installation of a group of pumping wells at optimum spacing and pumping rates to create a "capture zone" for recovery of hexavalent-chromium contaminated groundwater. This zone of recovered groundwater would be designed to be of sufficient size to control and contain the area of groundwater with the highest concentrations of chromium – deemed to be the "source area" or "hot spot" of the chromium-contaminated plume. The source area is defined as that area of the plume containing concentrations of 5,000 µg/L or greater. Contaminated groundwater would be pumped from a series of 7 extraction wells to a surface treatment system which would remove chromium through ion exchange treatment. The pump and treat system would operate for an estimated 5 years, pumping at a rate of 30 gallons per minute. Contaminated groundwater outside of the source area would be left to disperse and dilute to acceptable levels (50 µg/L). Institutional controls and monitoring would be completed as discussed in Alternative 2. Monitoring would be required until groundwater meets state MTCA A groundwater standards. Monitoring for 30 years has been included in the cost estimate in Section 9.

Alternative 4 – In-situ ISRM Treatment Barrier, Institutional Controls, Monitoring: This alternative consists of constructing a treatment barrier wall using In-situ Redox Manipulation (ISRM) technology down-gradient of the soils source area (hexavalent chromium concentrations exceeding 19 mg/kg) to intercept and reduce hexavalent chromium to trivalent chromium. ISRM treatment technology for hexavalent chromium consists of delivering a chemical reductant into the aquifer or soil matrix to reduce the naturally occurring iron, thereby creating an in-situ reactive treatment zone which reacts directly with the chromium. As chromium-contaminated groundwater passes through the reactive zone, the hexavalent chromium is reduced, or changed, to trivalent chromium, which is insoluble, and non-mobile. At the FHC site, reductant would be injected or augered into the groundwater immediately down-gradient of the plume "hot spot" as detailed in Figure 13. Injection of reductant into this area, the most likely method of reductant delivery, would require approximately 11 injection wells. Based upon a site-specific soil analysis conducted by Battelle Northwest, the barrier is predicted to remain active for approximately 30 years. If the barrier becomes saturated and ceases to function before up-gradient groundwater achieves state groundwater cleanup standards, reinjection of reductant would be required to recharge the barrier wall. Costs for potential reinjection are not included in the estimate below. Contaminated groundwater outside of the source area would be left to disperse and dilute to acceptable levels (50 µg/L). Institutional controls and monitoring would be completed as discussed in Alternative 2. Monitoring and institutional controls would be completed as discussed in Alternative 2. Monitoring for 30 years has been included in the cost estimate in Section 9.

A by-product of the reactions created by reductant injection is sulfate. The maximum concentration of sulfate predicted to be generated through this process is 2000 mg/L, or 8 times the secondary state Maximum Contaminant Level (MCL) standard of 250 mg/L. Conservative

modeling indicates that the maximum sulfate concentrations will dilute and disperse to the secondary standard approximately 1000 feet down-gradient within approximately 400 days. In other words, sulfates would create a temporary impact to groundwater within the already contaminated groundwater plume. As this alternative utilizes the injection of reductants into the groundwater, it must comply with WAC 173-218 - the Underground Injection Control Program - which sets forth procedures and practices applicable to the injection of fluids through wells. If sulfate concentrations are higher than expected, EPA will explore alternative methods such as extracting the sulfates as they are generated. Alternative methods have not been evaluated for cost, and are not reflected in the cost estimates in Section 9.

Alternative 5 – In-situ Reduction of Hexavalent Chromium in Groundwater Source Area, Institutional Controls, Monitoring: Like Alternative 4, this alternative would involve the delivery of a reducing chemical directly into the soils and groundwater of the groundwater source area, directly converting hexavalent chromium to trivalent chromium. The reductant would be injected or augered/injected into the plume "hot spot" in the aquifer as detailed in Figure 14. If injection is used, approximately 18 injection wells would be required to deliver reductant to the entire plume hot spot. Contaminated groundwater outside of the source area would be left to dilute and disperse to acceptable levels (50 µg/L). Monitoring and Institutional Controls would be completed as discussed in Alternative 2. Groundwater monitoring is estimated to be necessary for a period of 15 years. Again, generation of sulfates would occur as a result of the chemical reactions taking place, and downstream monitoring during injection or augering would be required to ensure that sulfate levels will dilute and disperse as predicted. If augering/injection is used, on site structures would need to be removed prior cleanup.

9.2 Soils

All active soil remediation alternatives focus on the soils source area, or that area defined by concentrations of hexavalent chromium in excess of 19 mg/kg as detailed in Figure 7. The soils source area covers approximately 28,000 square feet and extends to approximately 25 feet in depth for a total volume of 26,000 cubic yards.

Alternative 1 - No Action: The no-action alternative consists of doing nothing to the contaminated soils at FHC. No controls would be put in place to prevent human health exposure or protect the environment.

Alternative 2 – Institutional Controls/Monitoring: This alternative would involve installing signs on the facility to warn workers and business employees of contamination in surface and subsurface soils. Signs would warn against digging or excavation without proper conformance to environmental laws. Deed notices and restrictions would also warn potential buyers of the presence of subsurface soil contamination and would limit the use of the property to industrial purposes. In addition, deed restrictions would require remedial actions to prevent exposure to contaminated soil beneath buildings if building demolition occurs as a result of future property development. Fences around the property would keep out trespassers who could inadvertently

be exposed to contaminated soils. Property owners would ensure that any future property transfers would include the deed restrictions described above.

Alternative 3 – Capping: This alternative consists of placing an asphalt layer over the contaminated soil exceeding 19 mg/kg of hexavalent chromium to provide separation from human contact and reduce leaching of chromium from soils to groundwater. The area to be capped would likely be confirmed through surface and subsurface soil sampling during remedial design. Based on current information, it is assumed that an area approximately 200 by 155 feet, or 31,000 square feet, would be paved if buildings are removed. If the buildings remain in place, the area to be capped would be reduced by the area covered by the buildings. Annual inspection and periodic maintenance of the cap would be required to ensure that any large cracks that developed were repaired. Monitoring for 20 years has been included in the cost estimate in Section 9. Institutional controls would be implemented as described in Alternative 2.

Alternative 4 – Soil Excavation, Removal, and Disposal: This alternative involves the excavation of the most heavily impacted soils, or soils containing hexavalent chromium in excess of 19 mg/kg. Based upon current information, approximately 26,000 cubic yards of soil would need to be excavated and disposed of at a permitted facility. To obtain access to the soil, two buildings - the former FHC building and the Richardson Metal Works building - would have to be demolished. After the soil is removed for disposal, clean backfill would be placed in the hole.

Alternative 5 – Soil Excavation, Stabilization, and Replacement (Selected Alternative from 1987 ROD): This alternative involves the excavation and on-site stabilization of soils using concrete to minimize leaching of chromium. Stabilized soils would then be returned to the excavated site. As with Alternative 4, two buildings would have to be demolished to obtain access to contaminated soils.

Alternative 6 – In-situ Treatment of Soils Using Reducing Chemicals: This alternative consists of injecting or augering a chemical reductant into source area soils to reduce the hexavalent chromium in the soils source area to trivalent chromium as detailed in Figure 15. Chemical reductants would either be injected through vertical or horizontal injection wells, or mixed directly with on site soils using an auger. Use of vertical injection or augering/injection would require demolition of on site buildings. Horizontal injection could be used with the buildings in place. Some institutional controls and monitoring would be required as described in Alternative 2. 15 years of monitoring has been included in the cost estimate in Section 9. As with groundwater alternatives that use reductants, sulfates would be generated as a result of the chemical reactions taking place.

10.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

10.1 Evaluation Criteria

The Selected Alternative for the cleanup of soils and groundwater at the FHC Site was chosen on the basis of the remedial alternative evaluation criteria found in the NCP. The nine criteria are divided into three categories: threshold, balancing, and modifying criteria. To be eligible for selection, an alternative must meet the two threshold criteria. The five balancing criteria weigh trade-offs among alternatives; a low rating on one balancing criterion can be compensated by a high rating on another. The final modifying criteria are considered after the public comment period during selection of the final remedy. These nine criteria are presented below and explained in further detail.

Threshold Criteria: Must be met to be eligible for selection

Overall Protection of Human Health and the Environment. How well does the alternative protect human health and the environment, both during and after construction?

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs). Does the alternative meet requirements of state and federal laws and regulations that apply or that are relevant and appropriate to the cleanup action?

Balancing Criteria: Used to compare alternatives

Long-term effectiveness and permanence. How well does the alternative protect human health and the environment after completion of the cleanup? What, if any, risks will remain at the site?
Reduction in toxicity, mobility, and volume through treatment. Does the alternative effectively treat the contamination to significantly reduce the toxicity, mobility, and volume of the hazardous substances?
Short-term effectiveness. Are there potential adverse effects to either human health or the environment during construction or implementation of the alternative?
Implementability. Is the alternative both technically and administratively feasible? Has the technology been used successfully at similar sites?
Cost. What are the relative costs of the alternative?

Modifying Criteria: Evaluated as a result of public comments.

State acceptance. What are the state comments or concerns about the alternatives considered and about the Preferred Alternative in the Proposed Plan? Does the state support or oppose the Selected Remedy in the Amended ROD?
Community acceptance. What are the community's comments or concerns about the alternatives considered and about the Preferred Alternative in the Propose Plan? Does the community generally support or oppose the Preferred Alternative in the Proposed Plan?

10.2 Comparative Analysis of Alternatives

Overall Protection of Human Health and the Environment

- **Groundwater**

Alternative 1 (No Action) does not provide any degree of protection for human health and the environment. Alternative 2 (Institutional Controls/Monitoring) provides minimal protection of human health by warning potentially affected parties of the site hazards and restricting access to the FHC Site and areas affected by the groundwater plume. Alternatives 3 (Pump and Treat), 4 (ISRM Treatment Barrier) and 5 (In-situ Reduction of Hexavalent Chromium in Groundwater Source Area) all provide protection of human health and the environment by either treating or containing contaminated groundwater in the plume "hot spot". Alternatives 3, 4 and 5 also provide for institutional controls and monitoring as the remaining plume disperses and dilutes to state groundwater cleanup standards.

- **Soils**

Alternatives 1 (No Action) and 2 (Institutional Controls/Monitoring) do little or nothing to protect human health and environment. Alternative 2 provides minimal to moderate protection to humans by warning of risks associated with dermal contact or ingestion of contaminated soil. Alternative 5 (Stabilization with Concrete) has been shown to be ineffective at preventing mobilization of hexavalent chromium to groundwater in site specific stabilization tests conducted in 1991. Alternative 3 (Capping), while effective at limiting dermal contact and ingestion, would do nothing to prevent continued leaching of contaminants from subsurface soils to groundwater. Alternatives 4 (Removal/Disposal) and 6 (In-situ Treatment of Soils Using Reducing Chemicals) are protective of human health and the environment. In-situ treatment and removal prevent human contact with affected soils and prevent leaching of contaminants to groundwater.

Compliance with ARARs

- **Groundwater**

The primary ARARs for all groundwater alternatives are federal MCLs and MTCA state groundwater cleanup standards. Alternatives 3 (Pump and Treat), 4 (ISRM Treatment Barrier) and 5 (In-situ Reduction of Hexavalent Chromium in Groundwater Source Area) all utilize technologies that meet ARARs by employing methods which reduce groundwater contamination near the source and prevent further migration of contaminants down-gradient (assuming remediation of source area soils). Alternatives 4 and 5 both utilize the injection of reductants into the groundwater and must comply with WAC 173-218 - the Underground Injection Control Program - which sets forth procedures and practices applicable to the injection of fluids through wells. Alternatives 1 and 2 do not comply with ARARs. Alternatives 1 and 2 do not comply with cleanup goals or address site risks.

- **Soils**

The primary ARARs for all soil alternatives are the state standards for protection of human health through direct contact and protection of groundwater. Alternatives 1 and 2 do not comply with ARARs. Neither alternative addresses groundwater protection or direct contact associated with chromium-contaminated soil. Both alternatives leave contamination on site above MTCA cleanup requirements with no exposure reduction. Alternative 5 does not comply with ARARs as leachate to groundwater would not be controlled with cement stabilization of contaminated soils. Alternative 3 reduces infiltration of groundwater but would not prevent groundwater contact with contaminated subsurface soils and in the long-term would likely prove ineffective at preventing infiltration. Alternatives 4 and 6 comply with ARARs. Both alternatives meet the soil cleanup goal of 19 mg/kg hexavalent chromium for protection of groundwater.

Groundwater Alternatives 1 (No Action) and 2 (Institutional Controls/Monitoring), and soil Alternatives 1 (No Action), 2 (Institutional Controls/Monitoring), 3 (Capping), and 5 (Stabilization), all fail at least one of the Threshold Criteria and will not be carried forward for further evaluation.

Long-Term Effectiveness and Permanence

- **Groundwater**

Alternative 3 (Pump and Treat) has good long-term effectiveness because the contaminants are removed from the groundwater and disposed of off site. Alternatives 4 (ISRM Treatment Barrier) and 5 (In-situ Reduction of Hexavalent Chromium in Groundwater Source Area) have very good to excellent long term effectiveness because contaminants are converted to a non-toxic and immobile form of chromium in-situ. Alternative 4 may be less effective long term than Alternative 5 because groundwater up-gradient of the treatment barrier may not meet state groundwater cleanup standards before the treatment barrier expires. If the treatment barrier expires, reinjection would be required.

- **Soils**

Alternative 4 (Removal/Disposal) provides excellent long-term protection by permanently removing contaminated soils from the site. Alternative 6 has very good to excellent long- term effectiveness because contaminants are converted to an immobile form in-situ. Soil mixing in Alternative 6 (In-situ Treatment of Soils Using Reducing Chemicals) is preferable to horizontal or vertical injection as the latter methods may not effectively deliver the reducing chemicals to all affected soils - particularly denser soils such as clay where the highest concentrations of chromium are located.

Reduction in toxicity, mobility, and volume through treatment

- **Groundwater**

Alternative 3 (Pump and Treat) reduces toxicity and mobility through removal of the contaminant from the groundwater and ion exchange treatment. Alternatives 4 (ISRM Treatment Barrier) and 5 (In-situ Reduction of Hexavalent Chromium in Groundwater Source Area) reduce the mobility and toxicity through treatment, causing changes to the physical state of the contaminant.

- **Soils**

Alternative 4 (Removal/Disposal) reduces the mobility of contaminants by completely removing them from the site and treating as necessary to comply with disposal regulations. Alternative 6 (In-situ Treatment of Soils Using Reducing Chemicals) provides reduction in mobility and toxicity through treatment, causing changes to the physical state of the contaminant.

Short-term Effectiveness

- **Groundwater**

Alternative 3 (Pump and Treat) has the lowest short-term effectiveness due to the construction required for pump and treat and the potential exposure of workers to the cleanup operation. Alternatives 4 (ISRM Treatment Barrier) and 5 (In-situ Reduction of Hexavalent Chromium in Groundwater Source Area) have high short-term effectiveness as excavation work is minimized, reducing off-site exposure to dust; and off-site disposal is insignificant, reducing the potential for traffic accidents during cleanup. If augering/injection is used for Alternative 5, occupants from the FHC and Richardson Metals buildings would need to be relocated and the buildings demolished. If augering/injection is used for Alternatives 4 or 5, temporary, localized non-toxic odors may result from injection/mixing of reductants into surface soils. All the alternatives will minimally impact neighboring businesses with some increase in traffic and noise. Apart from monitoring, Alternatives 4 and 5 have relatively shorter implementation periods (approximately 6 months) than Alternative 3 (5 years). Alternatives 3 and 5 would help achieve groundwater cleanup water standards throughout the plume area in a relatively shorter period than Alternative 4 which does not directly impact the plume "hot spot" area.

- **Soils**

Alternatives 4 (Remove/Dispose) has the lowest short-term effectiveness due the amount of excavation required and resultant dust generation. Alternative 4 also requires significant truck traffic to haul soils off site. Alternatives 6 (In-situ Treatment of Soils Using Reducing Chemicals) has good short-term effectiveness as excavation and traffic are minimized. If augering/injection is used for Alternative 6, occupants from the FHC and Richardson Metals buildings would need to be relocated and the buildings demolished. If augering/injection is used

for Alternatives 4 or 5, temporary, localized, non-toxic odors may result from injection/mixing of reductants into surface soils. Both alternatives have relatively similar periods of implementation (approximately 6 months) and would both achieve cleanup objectives at the end of project implementation. Confirmatory sampling and monitoring would be required for both alternatives after project implementation.

Implementability

- **Groundwater**

Alternatives 4 (ISRM Treatment Barrier) and 5 (In-situ Reduction of Hexavalent Chromium in Groundwater Source Area) are the easiest to implement as intrusive work is kept to a minimum. If augering/injection is used for Alternative 5, tenants from on-site buildings would need to be relocated and the buildings demolished. Alternative 4 may face implementability issues arising from working at a site with potentially active facilities if the buildings are left in place. Both of these alternatives have been shown to be effective and implementable at other sites, particularly the Hanford site in Richland, Washington where an ISRM barrier is being used to treat chromium contaminated groundwater flowing to the Columbia River. Alternative 3 (Pump and Treat) is the most difficult to implement. In addition to installation of wells, it also requires installation of pipe trenches. Alternative 3 is more difficult to implement than Alternatives 4 and 5 because of the added complexity of the treatment system and the treated water disposal requirements.

- **Soils**

Alternatives 4 (Removal/Disposal) and 6 (In-situ Treatment of Soils Using Reducing Chemicals)- if augering is used - would be moderately difficult to implement as the buildings would need to be torn down. If augering/injection is used for Alternative 6, tenants from on-site buildings would need to be relocated and the buildings demolished. Alternative 6 using injection wells would be difficult to implement due to the impact on the businesses during construction, and a possible ineffective application under buildings. Working around the site businesses (requiring weekend and evening work schedules) in order to minimize disruption would severely impact implementation.

Cost

Cost of Soil and Groundwater Alternatives
All amounts adjusted to present value

Groundwater:	Construction Costs	Operation and Maintenance Cost (Total)	TOTAL PROJECT COSTS
Alternative 3 - Pump and Treat	$3,762,000	$1,638,000	$5,400,000
Alternative 4 - ISRM Treatment Barrier	$1,262,000	$173,000	$1,435,000
Alternative 5 - In-situ Treatment of Source Area	$2,670,000	$173,000	$2,843,000
Soils:			
Alternative 4 - Soil Excavation, Removal, Disposal	$8,678,000	$11,000	$8,689,000
Alternative 6 - In-situ Reduction of Chromium	$1,532,000	$154,000	$1,686,000

All costs are based on the July, 2000 Final Focused Feasability Study, with some minor revisions.

Total costs for Groundwater Alternatives 3, 4 and 5 include institutional controls and long term monitoring and maintenance for 30 years. Soil Alternative 4 assumes minimal maintenance and reporting beyond confirmatory sampling. Soil Alternative 6 assumes 15 years of monitoring and maintenance will be required.

Injection of reductants through wells is assumed for Groundwater Alternatives 4 and 5. Augering and injection of reductants is assumed for Soil Alternative 6.

Given the low probability of a potential recharge of the ISRM Treatment Barrier (Groundwater Alternative 4), costs for this contingency are not included.

The potential for excavation of contaminated soils in areas of potential auger refusal in Soil Alternative 6 - In-situ Reduction of Chromium - have not been included. Best professional judgement based upon sampling information indicates the probability of auger refusal to be low.

Costs for potential relocation of tenants due to building demolition have not been included for Soil Alternatives 4 and 6. Costs for building demolition have been included in Soil Alternatives 4 and 6.

State Acceptance

The Washington State Department of Ecology has been involved with the development of remedial alternatives for soils and groundwater at the Frontier Hard Chrome Superfund Site and agrees with the Selected Remedy presented in this Amended ROD.

Community Acceptance

During the pubic comment period for the Proposed Plan for this Amended ROD, EPA received one comment letter with two comments. The comment letter was generally supportive EPA's Selected Remedy but requested additional information concerning 1) the type and toxicity of potential by-products generated through the injection of sodium dithionite into contaminated site groundwater; and 2) the potential methods used for delivering reductants to the unsaturated vadose zone of contaminated soils. For further information concerning these comments, and EPA's responses, refer to the Responsiveness Summary in Part III of this Amended ROD.

10.3 Summary of Comparative Analysis

The remedial alternatives matrix below provides a summary of combined soil and groundwater alternatives, highlighting those combinations which are potentially protective of human health and the environment.

Remedial Alternatives, Media and Technology Evaluation Matrix

	Groundwater Alternatives				
Soil Alternatives	**Alternative 1, No Action**	**Alternative 2, Institutional Controls**	**Alternative 3, Pump and Treat**	**Alternative 4, ISRM Treatment Barrier**	**Alternative 5, In-situ Treatment of Source Area**
Alternative 1, No Action	Not protective as source area soils and plume "hot spot" continue to present threat to groundwater	Not protective as source area soils and plume "hot spot" continue to present threat to groundwater	Not protective as source area soils continue to present threat to groundwater	Not protective as source area soils continue to present threat to groundwater	Not protective as source area soils continue to present threat to groundwater
Alternative 2, Institutional Controls	Not protective as source area soils and plume "hot spot" continue to present threat to groundwater	Not protective as source area soils and plume "hot spot" continue to present threat to groundwater	Not protective as source area soils continue to present threat to groundwater	Not protective as source area soils continue to present threat to groundwater	Not protective as source area soils continue to present threat to groundwater
Alternative 3, Capping	Not protective as source area soils continue to present threat to groundwater	Not protective as source area soils continue to present threat to groundwater	Not protective as source area soils continue to present threat to groundwater	Not protective as source area soils continue to present threat to groundwater	Not protective as source area soils continue to present threat to groundwater
Alternative 4 Soil Excavation, Removal, Disposal	Not protective as plume "hot spot" remains untreated	Not protective as plume "hot spot" remains untreated	Protective but excessive in terms of cost ($14,089,000)	Protective but excessive in terms of cost ($10,124,000)	Protective but excessive in terms of cost ($11,532,000)
Alternative 5, Stabilization with Concrete	Not protective as source area soils continue to present threat to groundwater	Not protective as source area soils continue to present threat to groundwater	Not protective as source area soils continue to present threat to groundwater	Not protective as source area soils continue to present threat to groundwater	Not protective as source area soils continue to present threat to groundwater
Alternative 6, In-situ Reduction of Chromium	Not protective as plume "hot spot" remains untreated	Not protective as plume "hot spot" remains untreated	Protective ($7,086,000)	Protective ($3,121,000)	Protective* ($2,191,800)

*Cost assumes that augering/injection of source area soils is extended an additional 10 feet in depth for treatment of plume "hot spot" area. Additional construction costs and reductant costs beyond Soil Alternative 6 are conservatively estimated to be 30% of Soil Alternative 6 costs based on the additional area to be treated.

- **Groundwater**

Alternatives 1 and 2, No Action and Institutional Controls, for groundwater are not protective of human health and the environment, and are thus not considered to be appropriate alternatives for the Site. Alternative 3 for groundwater, Pump and Treat, is an effective remedy for site groundwater, but would require more time to implement (5 years), and costs significantly more than (approximately $3,200,000 more than In-Situ Treatment through augering) In-situ Treatment. Alternative 4, In-situ ISRM Treatment Barrier, is an effective containment remedy, but does not treat plume "hot spot" groundwater and must be recharged and maintained if concentrations in groundwater up-gradient of the barrier persist beyond the life of the barrier. If no cleanup takes place, soil concentrations in the source area are likely to remain extremely high, and would continue to act as a source to groundwater, and a threat down-gradient should the treatment barrier become less effectiveness. Alternative 5, In-situ Treatment of Source Area groundwater, provides for the effective treatment of all groundwater exceeding 5,000 µg/L. All protective groundwater remedies must be implemented in conjunction with protective soil remedies in order to remain effective over the long term and prevent recontamination of the groundwater.

- **Soils**

Alternatives 1 and 2, No Action and Institutional Controls, for soils is not protective of human health and the environment, and are thus not considered to be appropriate alternatives for the Site. Alternative 5 for soils, Stabilization with concrete, has already been shown through studies to be ineffective at immobilizing hexavalent chromium. Alternative 3 for soils, Capping, reduces infiltration of groundwater but does nothing to prevent continued leaching of contaminants from saturated soils. Capping must also be maintained in perpetuity, and will restrict future use of the property. Alternative 4 for soils, Excavation, provides for complete removal of contaminated soils in the source area, but at very high cost. Alternative 6 for soils, In-situ Treatment, provides: 1) excellent overall protection of human health and the environment, 2) long term effectiveness, 3) permanence, 4) reduction in toxicity, and mobility, and 5) state acceptance, at a significantly lower cost than excavation. Cost assumptions for implementation of soil Alternative 6 in conjunction with groundwater Alternative 5 imply joint treatment of source area soils and groundwater in, and beneath, the soils source area through augering/injection. All protective soil remedies must be implemented with protective groundwater remedies to remain effective over the long term and prevent recontamination of source area soils below the water table.

11.0 SELECTED REMEDY (Figure 16)

Alternative 5, In-situ Treatment of Source Area groundwater, in conjunction with Alternative 4, ISRM Treatment Barrier, is the Selected Remedy for groundwater. Alternative 6, In-situ Treatment, is the Selected Remedy for soils. Treatment of soils (Soil Alternative 6) and treatment of Source Area groundwater (Groundwater Alternative 5), is accomplished at the same time using the same method to deliver the same chemical reductant. The preferred methodology for delivering reductant to both soils and groundwater for in-situ treatment in the soils source area and the plume hot spot is augering/injection. The ISRM Treatment Barrier (Groundwater Alternative 4) would be installed on the down-gradient edge of the groundwater hot spot prior to the in situ treatment of soils and groundwater specified in Groundwater Alternative 5 and Soil Alternative 6. The ISRM Treatment Barrier could be installed using injection wells or augering. Groundwater contaminated above state cleanup standards which is down-gradient of the ISRM Treatment Barrier would be left to disperse and dilute. The combination of these alternatives would allow for the treatment of groundwater and soils in the soils source area (soils exceeding 19 mg/kg hexavalent chromium) and the groundwater plume "hot spot" (groundwater exceeding 5,000 µg/L) at the same time using the same reductant and the same methodology (augering) with additional construction and reductant costs (30% of soil Alternative 6 costs, or $505,800) beyond soil Alternative 6. These additional costs account for the additional depth of augering and chemical reductant required to treat groundwater beneath the soils source area. Installation of an ISRM barrier prior to the in situ treatment of soils and groundwater specified in Groundwater Alternative 5 and Soil Alternative 6, provides additional long term protection of groundwater as well as protection of down-gradient groundwater during augering/injection of reductant into source area soils and the plume "hot spot" area. This alternative provides for effective treatment of all soils and groundwater in source areas, and a 30-year treatment barrier for any residual contaminant leaching, should it occur. The total estimated cost for the Selected Remedy is $3,626,800 ($1,686,000 [costs for Soil Alternative 6] + .3 X $1,686,000 [or 30% of Soil Alternative 6 costs to account for the additional depth of auger/injection to address groundwater] + $1,435,000 [the cost of Groundwater Alternative 4]) assuming the ISRM barrier is installed using injection wells. Additional cost savings of approximately $500,000 could be realized if the ISRM barrier were installed through augering/injection on the down-gradient side of the soils source area as part of soil Alternative 6, for a total Selected Remedy cost of $3,126,800. Detailed evaluation of both methods will be conducted during Remedial Design.

A by-product of the reactions created by reductant injection is sulfate. The maximum concentration of sulfate predicted to be generated through this process is 2,000 mg/L, or 8 times the secondary state Maximum Contaminant Level (MCL) standard of 250 mg/L. Conservative modeling indicates that the maximum sulfate concentrations will dilute and disperse to the secondary standard approximately 1000 feet down-gradient within approximately 400 days. In other words, sulfates would create a temporary impact to groundwater within the already contaminated groundwater plume. Because this alternative utilizes the injection of reductants into the groundwater, it must comply with WAC 173-218 - the Underground Injection Control Program - which sets forth procedures and practices applicable to the injection of fluids through wells. If sulfate concentrations are higher than expected, EPA will explore alternative methods

such as extracting the sulfates as they are generated. Alternative methods have not been evaluated for cost, and are not reflected in the cost estimates in Section 9.

The Selected Remedy calls for the reduction of hexavalent chromium in soils and groundwater to trivalent chromium. Upon completion of the remedy, concentrations of trivalent chromium in subsurface soils will remain as high as 31,800 mg/kg. Hexavalent chromium is both extremely soluble under normal groundwater conditions (pH ~ 7), mobile and a carcinogen. When the valence state of chromium is changed from +6 to +3 using a reductant, chromium forms the compound chromium hydroxide which is insoluble under normal groundwater conditions and in small quantities is an essential nutrient. Through use of reductants, as discussed above, hexavalent chromium would be converted to the insoluble form of trivalent chromium almost instantaneously, immobilizing it in the subsurface and immediately reducing chromium concentrations in groundwater to non-detectable concentrations. Even the highest concentrations of trivalent chromium that would remain on site after reduction of hexavalent chromium would not exceed the state MTCA B unrestricted use level of 80,000 mg/kg. EPA will demonstrate that this value is also protective of groundwater through historical data evaluation, modeling, and future monitoring.

The following are major components of the Selected Remedy:

- Contain Highly-Contaminated Groundwater: Containment of the most heavily contaminated groundwater at the site, or groundwater "hot spot" will involve the delivery, through injection or augering/injection, of reducing compounds on the down-gradient side of the soils source area, into the groundwater and soils. The compounds delivered to the area will reduce the naturally occurring iron, thereby creating an in-situ treatment barrier which reacts directly with the chromium in groundwater. As chromium-contaminated groundwater moving down-gradient passes through the permeable reactive zone, the hexavalent chromium in the groundwater is reduced to trivalent chromium, which is insoluble, and non-mobile. This In-Situ Redox Manipulation (ISRM) barrier will be in place prior to treatment of the soils source area and the groundwater plume "hot spot" in order to 1) provide containment of the groundwater "hot spot" as quickly as possible, 2) provide added protection during the in-situ treatment of the soils source area and the groundwater "hot spot" to prevent hexavalent chromium from moving down-gradient; and 3) provide long-term protection against future leaching of hexavalent chromium, should it occur. Reducing compounds will either be injected through a series of wells, or augered/injected into the groundwater. Recharge of the ISRM barrier is not anticipated because the soils source area up-gradient of the ISRM barrier will also be treated as described below. It is unlikely that residual concentrations of chromium in the soils source area, should they exist after treatment, will pose a problem beyond the predicted life of the ISRM barrier.
- In-Situ Treatment of Source Area Soils and Groundwater "Hot Spot": In-situ treatment of the soils source area and the groundwater "hot spot" will involve the deliver of reducing compounds directly to site soils exceeding 19 mg/kg hexavalent chromium (soils source

area) and contaminated groundwater with concentrations of hexavalent chromium exceeding 5,000 µg/L by augering/injecting or through injection wells. Augering/injection is the most likely method of delivery given the cost savings and the thorough mixing of reductant with soils the augering provides.[4]

- After treatment of soils exceeding 19 mg/kg and groundwater exceeding 5,000 µg/L, compaction of augered soils will be provided to allow for future use of the property to the extent practicable.
- Once the source area for soils (exceeding 19 mg/kg hexavalent chromium) and groundwater (exceeding 5,000 µg/L hexavalent chromium) have been treated, remaining groundwater exceeding the state groundwater cleanup standard of 50 µg/L is expected to disperse and dilute (MTCA Method A). Regular monitoring of down-gradient groundwater to ensure dilution and dispersion of affected groundwater outside of the source area will be conducted until all remaining groundwater meets state standards for groundwater cleanup.
- Institutional controls and monitoring will be implemented to protect human health and the environment during the time required for dispersion and dilution to reduce chromium concentrations in plume areas outside of the "hot spot". Monitoring of the hot spot area will also be conducted to ensure that recontamination of treated areas is not taking place. In addition to the state and local institutional controls already in place described in the "Summary of Site Risks" section, other institutional controls to be considered include placing notices and restrictions on property deeds. Institutional controls will be evaluated during Remedial Design and after Remedial Action as all of the necessary information becomes available. In general, institutional controls will serve to prevent 1) access to contaminated groundwater, 2) access to soils contaminated with residual concentrations of hexavalent chromium above state MTCA A standards should these concentrations remain after Remedial Action, and 3) future activities that threaten to remobilize chromium in site soils. Concentrations of trivalent chromium remaining in soils after Remedial Action will also be evaluated to determine if they pose any potential risks to human health through direct contact. Property owners would ensure that any future property transfers would include appropriate deed restrictions. Monitoring of existing wells will also be needed to track the concentrations in groundwater over time. Monitoring of existing wells will also be needed to track the concentrations in groundwater over time.

The implementation of the remedy will be phased with the installation of the ISRM treatment barrier being conducted in the first phase to contain the groundwater "hot spot". This alternative is recommended because it addresses all source area soils and groundwater providing: 1) excellent overall protection of human health and the environment, 2) effectiveness long term, 3)

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[4]Delivery of reducing compounds throughout the soils source area and the groundwater "hot spot" will more than likely require direct access to contaminated soils. Direct access will necessitate the demolition of both the Frontier Hard Chrome building and the adjacent Richardson Metal Works building.

permanence, 4) compliance with ARARs, 5) reduction in toxicity, and mobility, and 6) state acceptance, at a lower cost than other protective alternatives. The remedy will provide a permanent solution to ongoing threats posed by the Frontier Hard Chrome site to the groundwater and future threats posed to human health and the environment.

Based on all of the information currently available, EPA believes the Selected Remedy provides the best balance of tradeoffs among the other alternatives with respect to the evaluation criteria.

12.0 STATUTORY DETERMINATIONS

Based on the information currently available, EPA believes the Selected Remedy provides the best balance of tradeoffs among the other alternatives with respect to the evaluation criteria. The Selected Remedy best satisfies the following statutory requirements in CERCLA Section 121(b): (1) be protective of human health and the environment; (2) comply with ARARs; (3) be cost-effective; (4) utilize permanent solutions; and (5) satisfy the preference for treatment as a principal element.

Under CERCLA Section 121 and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with applicable or relevant and appropriate requirements, are cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous substances as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the Selected Remedy meets these statutory requirements.

12.1 Protection of Human Health and the Environment

The Selected Remedy will protect human health and the environment through the treatment of contaminated soils and the most heavily contaminated groundwater by the injection or augering/injection of hexavalent chromium-reducing compounds with contaminated soils and groundwater, in-situ. The Selected Remedy actively treats the soils and groundwater by reducing hexavalent chromium, which is highly mobile and toxic, to trivalent chromium, which is generally immobile and non-toxic. This remedy will reduce the threat of exposure to hexavalent chromium-contaminated soils and groundwater through direct contact, ingestion, or inhalation.

12.2 Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)

The Selected Remedy will be designed and implemented to comply with all action specific, chemical specific, and location specific ARARs identified in this section. The ARARs for the Selected Remedy are also presented below:

Model Toxics Control Act, Selection of Cleanup Actions, WAC 173-340-360; Institutional Controls, WAC 173-340-440; Use of Method B Cleanup Standards, WAC 173-340-705; Ground Water Cleanup Standards, WAC 173-340-720; Soil Cleanup Standards, WAC 173-340-740 and 173-340-747

WAC 173-340-360 describes the minimum requirements and procedures for selecting cleanup actions. Section 360 is applicable to the Selected Remedy and will be demonstrated to be met to Ecology's satisfaction by the State of Washington's concurrence on the Amended ROD. WAC 173-340-440 applies where active cleanup measures will not attain MTCA cleanup levels. In this case, institutional controls, as discussed in Section 10.0, apply to the groundwater until groundwater cleanup standards are achieved. WAC 173.340, 720, 740, and 747 establish cleanup standards for groundwater and soil contaminants applicable to this site. The cleanup standards are applicable and are set forth in Section 7.1 of this Amended ROD will meet or exceed these MTCA cleanup standards.

The Safe Drinking Water Act National Primary Drinking Water Regulations, 40 CFR 141; Public Water Supplies, WAC 246-290

These regulations specify primary standards for drinking water (MCLs). They are applicable at the tap for municipal water supplies and they are relevant and appropriate for groundwater at the site since the Troutdale aquifer is used as a drinking water source. The groundwater cleanup goals for this site include restoring the groundwater to MTCA Method A standards for groundwater cleanup, which are more stringent than the MCL for chromium in groundwater.

Underground Injection Control Program (WAC 173-218)

This regulation sets forth procedures and practices applicable to the injection of fluids through wells. This regulation is applicable to the injection of reducing agents into site soils and groundwater according to the Selected Remedy.

Clean Water Act, 33 U.S.C. Part 1317; 40 CFR 403.5; Water Pollution Control Act, RCW 90.48; Water Resources Act, RCW 90.54; Grant of Authority Sewerage Systems, WAC 173-208

These regulations pertain to the off-site disposal of treated groundwater, and while not an ARAR because it would be an off-site activity, it is listed here for completeness. Extraction of groundwater down-gradient of the treatment area may be necessary during the implementation of the Selected Remedy to control the migration of sulfates generated from the treatment process. Extracted groundwater, if required, would most likely be discharged to the City of Vancouver's wastewater treatment system and will meet the requirements set forth in a permit. If discharge to the City of Vancouver wastewater treatment system is required, EPA will also meet the requirements of 40 CFR 403.5. This regulation prohibits the discharge of pollutants to publicly owned treatment works would that pass through the facility without treatment or that would interfere with the treatment works.

Water Well Construction Act, RCW 18.104; Minimum Standards for Construction and maintenance of Wells, WAC 173-160

These regulations specify requirements for well construction and abandonment intended to protect groundwater from contamination. These regulations are applicable to the construction of injection wells, extraction wells, and additional monitoring wells (if required); and the abandonment of existing and future wells, as required at the FHC site by the Selected Remedy.

General Regulations for Air Pollution Sources, WAC 173-400; Ambient Air Quality Standards for Particulate Matter (WAC 173-470); Southwest Washington Air Pollution Control Agency (SWAPCA) Regulations 400 and 490

WAC 173-400 establishes technically feasible and reasonably attainable standards that are generally applicable to the control and/or prevention of the emission of air contaminants. Additionally, the Ambient Air Quality Standards for Particulate Matter identify suspended particulate standards applicable to excavation activities associated with building demolition and other remedial activities at the FHC site.

Resource Conservation and Recovery Act, 42 U.S.C. Sections 6921-22; 40 CFR 261; 40 CFR Part 262 Subparts A, B, C, and D; 40 CFR Parts 264, Subparts I and J; Washington State Dangerous Waste Regulations, WAC 173-303-070, 173-303-170 to 200, 173-303-630

These regulations establish requirements for the proper designation, storage, treatment and disposal of hazardous waste. 40 CFR Parts 261 and 262 and WAC 173-303 apply to the proper designation and characterization of the hazardous waste managed at the site. There are several potential hazardous waste streams (RCRA characteristic) that may be managed at the site. These waste streams include:

- Demolished concrete from building foundations contaminated by soils with high concentrations of hexavalent chromium.
- Excess contaminated surface soil, debris and water from limited removal, as required, and/or equipment/personnel decontamination.
- Personal Protective Equipment contaminated with hexavalent chromium.

40 CFR Parts 261 and 262 and the corresponding state Dangerous Waste Regulations are applicable to any hazardous waste generated during the treatment of contaminated groundwater. These regulations require proper designation and characterization of hazardous waste. The Selected Remedy will comply with these regulations. In addition, 40 CFR Part 264, Subparts I and J are relevant and appropriate for the ground-water treatment portion of the Selected Remedy. These regulations, as well as the corresponding State Dangerous Waste Regulations, require proper use and management of containers and require appropriate controls on tank systems. While contaminated groundwater will be treated in-situ through injection or augering/injection, according to the Selected Remedy, extraction of groundwater to control sulfate migration down-gradient of the treatment area is possible. The Selected Remedy will comply with the substantive requirements for containers, and proper on-site storage of hazardous waste prior to off-site disposal, should this be necessary.

40 CFR Part 261 and 262 and WAC 173-303-070 also apply to the limited amount of chromium contaminated soil that may be disposed of off site, if the soil is classified as dangerous, hazardous, or extremely hazardous waste. EPA will meet the federal and state regulations requiring identification, proper handling and disposal of hazardous waste.

Solid Waste Management-Reduction and Recycling Act, RCW 70.95; Minimum Functional Standards for Solid Waste Handling, WAC 173-304.

These regulations establish requirements for the disposal of non-hazardous waste. All non-hazardous waste generated will be disposed of off-site in accordance with these regulations. Since disposal occurs off-site, this law and associated regulations technically are not ARARs. Non-hazardous waste generated during the implementation of the Selected Remedy will comply with these regulations.

Pollution Disclosure Act of 1971, RCW 90.52.040

This law requires that wastes are to be provided with all known, available, and reasonable methods of treatment prior to their discharge or entry into waters of the state, and are applicable to the potential disposal of treated groundwater extracted down-gradient of the treatment area. The extracted water will have been treated by an in-situ reduction zone (ISRM) prior to extraction, and prior to discharge to the City of Vancouver sanitary sewer. This in-situ treatment of groundwater prior to discharge will comply with the requirements of the law.

U.S. Department of Transportation 49 CFR Parts 171-180; Transportation of Hazardous Materials, WAC 446-50

These regulations establish requirements for transportation of hazardous materials. These regulations are applicable to the transportation of soil, concrete and other debris (if hazardous) to off-site disposal facilities and EPA will meet these requirements during FHC cleanup activities.

To Be Considered (TBC)

ARARs are promulgated, enforceable requirements that must be at a site if they are applicable or relevant or appropriate. Other types of information (e.g., advisories, criteria and guidance) that are not ARARs, however, may be useful and should be considered, as appropriate, if it helps to ensure protectiveness or is otherwise useful in designing a specific cleanup remedy. This information is commonly referred to as TBCs. The following documents are TBCs at this site:

Ecology Statistical Guidance for Ecology Program Managers, August 1992 (Ecology Publication 92-54) and Supplement 6.

This document provides guidance for statistical evaluation of sampling data when determining whether MTCA cleanup standards have been achieved. EPA will determine the particular application of this guidance for use at the FHC site as the sampling and analysis plan for confirmatory sampling is prepared.

12.3 Cost-Effectiveness

In EPA's judgment, the selected remedy is cost-effective and represents a reasonable value for the money spent. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness" (NCP Section 300.430(f)(1)(ii)(D)). This was accomplished by evaluating the "overall effectiveness" of those alternatives that satisfied the threshold criteria (i.e. were both protective of human health and the environment and ARAR-compliant). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness). Overall effectiveness of the Selected Remedy was determined to be proportional to its costs and hence this alternative represents a reasonable value for the money spent.

The estimated cost of the selected remedy ranges from $3,126,800 to $3,626,800. The lower end of the range assumes that the ISRM barrier wall is installed through augering/injection, while the upper end assumes that injection wells will be used. Both costs assume augering/injection for the remainder of the soils source area and plume "hot spot". Although the combination of Soil Alternative 6 (In-situ Reduction of Chromium) and Groundwater Alternative 5 (In-situ

Treatment of Source Area) is less expensive by itself, it does not provide 1) the containment/treatment of potential contaminant migration during treatment of groundwater through Groundwater Alternative 5; and 2) long term containment/treatment of residual hexavalent chromium contamination in soils/groundwater, should it persist after implementation of the remedy.

12.4 Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

EPA has determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the site. Of those alternatives that are protective to human health and the environment and comply with ARARs, EPA has determined that the Selected Remedy provides the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and a bias against off-site treatment and disposal and considering State and community acceptance. These determinations are described in Section 9, and summarized in Section 10, where EPA's Rationale is provided for the Selected Remedy components. Both soils and groundwater are treated in-situ through the injection, or augering/injection of reducing compounds. The Selected Remedy presents a safe, in-situ, alternative-treatment-technology solution to ex-situ treatment and off-site disposal alternatives.

12.5 Preference for Treatment as a Principal Element

The selected remedy will treat, in-situ, hexavalent chromium in both soils and groundwater which continue to serve as source material at the FHC site and that constitutes the remaining principal threat at the site. As a result, hexavalent chromium in soils exceeding MTCA A standards for unrestricted future use will be reduced to trivalent chromium, which is essentially immobile and nontoxic; and groundwater with concentrations of hexavalent chromium exceeding 5000 µg/L will also be reduced to trivalent chromium. Because treatment, in-situ, is the basis of the Selected Remedy, the CERCLA preference for treatment as a principal element is satisfied at this site.

12.6 Five-Year Review Requirements

Because this remedy will result in contaminants remaining in groundwater down-gradient of the groundwater plume "hot spot" above levels that allow for unrestricted future use, a review will be conducted within five years of the remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

12.7 Documentation of Significant Changes from the Preferred Alternative of the Proposed Plan

The Proposed Plan for this ROD Amendment was released for public comment in June, 2001. The Proposed Plan identified Alternative 5, In-situ Treatment of Source Area groundwater, in conjunction with Alternative 4, ISRM Treatment Barrier, as the Preferred Alternative for groundwater. The Proposed plan identified Alternative 6, In-situ Treatment, is the Preferred Alternative for soils. EPA reviewed all written comments submitted during the comment period. It was determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

PART III: RESPONSIVENESS SUMMARY

During the public comment period for the Frontier Hard Chrome Superfund Site Proposed Plan (June, 2001) EPA received one comment letter from the City of Vancouver. This comment letter is available in the Administrative Record for the Frontier Hard Chrome Superfund Site.

In the following Responsiveness Summary, EPA provides responses to the issues raised by the City of Vancouver. Comments are summarized or rephrased by EPA for clarity and brevity.

EPA would like to thank the City of Vancouver for providing comments. These comments have helped to highlight particular issues, and will assist EPA in the design and implementation phases of the project.

Comment 1: *What is not described fully in the fact sheet or the Proposed Cleanup Plan is the possible toxicity of the reducing chemicals and all the likely chemical byproducts or intermediate products. The expected end product, sulfate, is discussed, and projected to be present at up to 8 times the Washington State secondary Maximum Contaminant Level - 2000 mg/l v. 250 mg/l. To build public confidence in the Plan, EPA should carefully assess and describe both the toxicity and fate of the injected chemicals and all expected reactants. Possible reactions between the injected chemical and naturally occurring organic matter in the upper soil zone should also be assessed.*

Response to Comment 1:

As described in the Selected Remedy (Section 10 of the Amended ROD), based upon modeling results, EPA expects sulfates remaining in groundwater after the dithionite decomposition to disperse and dilute to the secondary state MCL of 250 mg/L within approximately 400 days. During the period while dispersion/dilution is taking place, concentrations of sulfate exceeding the criteria will be located well within the down-gradient FHC plume which is contaminated with concentrations of hexavalent chromium exceeding state groundwater cleanup standards. Sulfate concentrations will dilute/disperse to the appropriate concentrations well in advance of groundwater recovery in the same area for hexavalent chromium. The Selected Remedy will also monitor concentrations of sulfate in groundwater down-gradient of the ISRM treatment barrier. If concentrations appear higher than expected and previously modeled, EPA will consider the use of extraction wells to remove the sulfates.

As described in Section 6 of the Amended ROD, city, state and local institutional controls are currently in place to prevent access to the contaminated aquifer. While it may be possible for a new well to be installed, or an existing well to be reactivated, which accesses the contaminated plume, it is unlikely. If the aquifer were to be used by a party unaware of the existing guidelines and regulations, the primary contaminant of concern would remain hexavalent chromium - not sulfates.

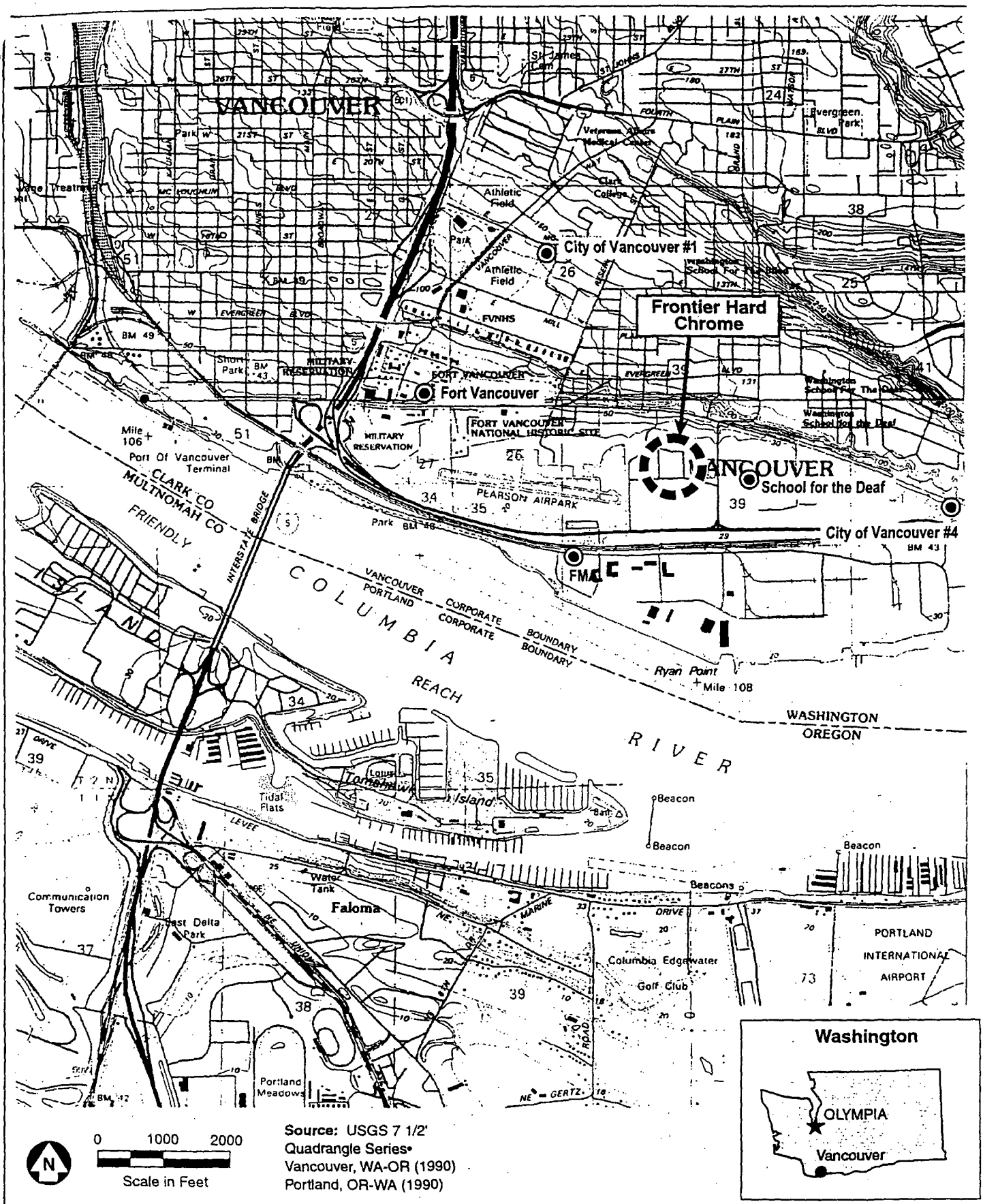
Sodium dithionite ($Na_2S_2O_4$) in its dissolved form in water is non-toxic, and is shipped in commerce in non-placarded tanker trucks. In its dry powder form, it is a listed dangerous waste, because of the characteristic of ignitability. In water solution, this is not a problem. Expected decomposition products in the subsurface environment under the pH and concentration condition employed by the In Situ Redox Manipulation process are sulfite, thiosulfite and sulfate. The dithionite is injected at fairly high concentration (~0.01 M or ~ 1,700 ppm) and allowed to react for approximately 2 days, until dithionite can no longer be detected. Typically at this time, the spent reagent is about half sulfate, and half sulfite, with about 1% -2% thiosulfate. Sulfite and thiosulfite are typically oxidized by dissolved oxygen in the aquifer.

Comment 2: *An aspect of the Proposed Plan that should be described more fully is the in-situ treatment of soils above groundwater. If the augering method of mixing is used, will the vadose zone soils remain unsaturated, or will a significant amount of water be added to facilitate the reaction between the chemical and the existing hexavalent chrome? Currently, not enough detail regarding the mixing step is provided to allow interested parties to assess that portion of the cleanup.*

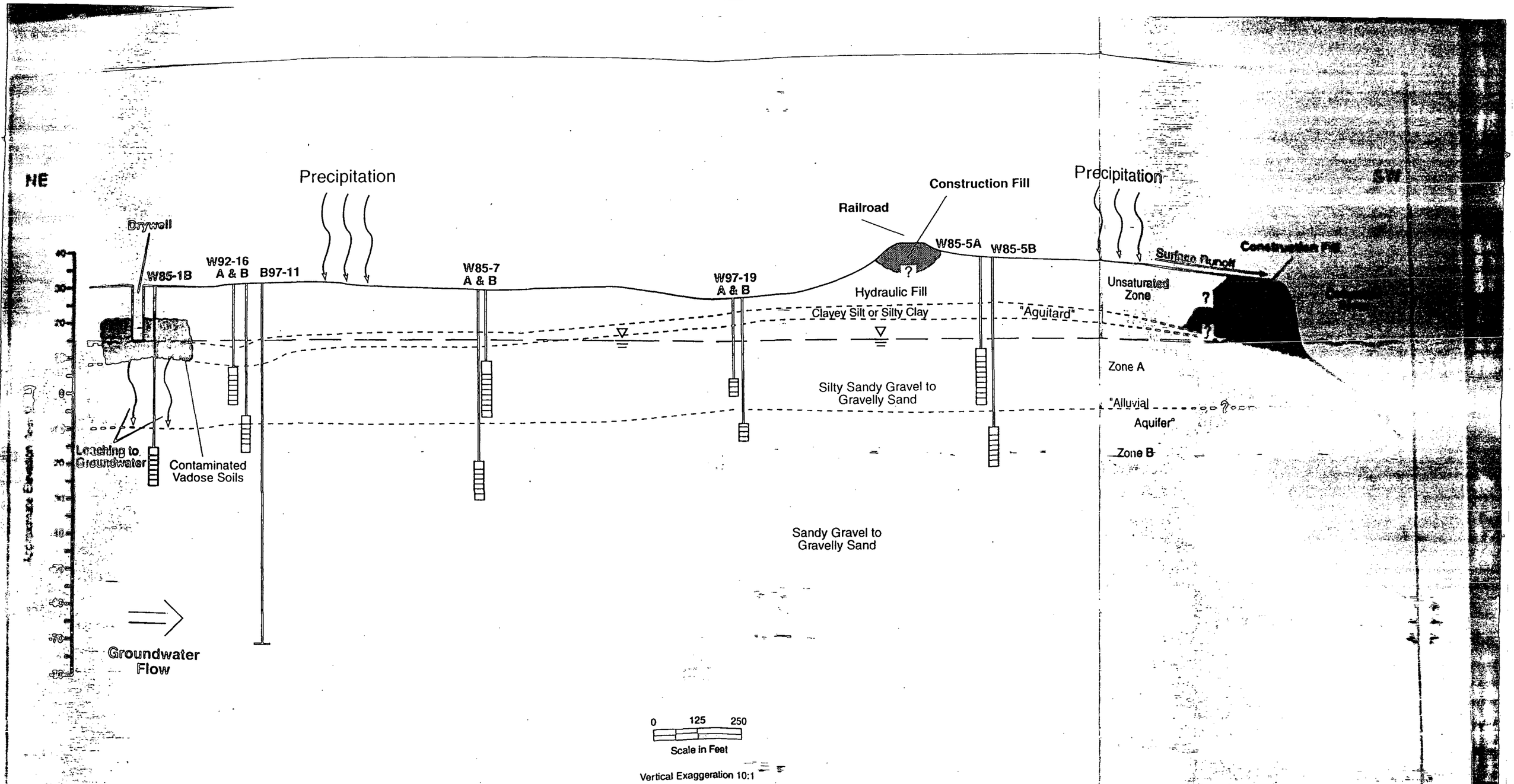
Response to Comment 2: Treatment of soils in the unsaturated zone is a key design issue. Of primary concern is the potential flushing of contaminants from the source soils into the aquifer during implementation of the remedy; and ensuring adequate exposure of all contaminated soils in the unsaturated zone to the reducing agents. While these issues will be addressed in greater detail during design, it is important to note:

- The Remedial Action will occur in phases. The first phase will be the installation of the ISRM treatment barrier on the down-gradient edge of the soils source area and the groundwater "hot spot". The ISRM treatment barrier is installed in the saturated zone only, and will be effective prior to treatment of source area soils and groundwater. Once the treatment phase for source area soils and groundwater begins, any contaminants that may be flushed into groundwater as a result of the process will encounter the ISRM treatment barrier, and reduce prior to moving further down-gradient.
- Reductants augered into the unsaturated zone will be in liquid form. The amount of liquid used will depend upon a number of factors including the time of year (which affects the amount of moisture present in the unsaturated zone) and the results of Remedial Design.
- The Remedial Design will evaluate the potential for injecting/augering from the saturated zone up through the unsaturated zone. If this method appears feasible and effective for treatment, it would provide an additional measure of safety in controlling the movement of contaminants. Through this method, contaminants potentially mobilized during injection in the unsaturated zoned would encounter a column of treated sediment/groundwater in advance of the ISRM barrier.

FIGURES



EPA REGION 10	Figure 1 Frontier Hard Chrome Superfund Site Vicinity Map	033-RI-CO-1027 Frontier Hard Chrome PROPOSED PLAN



Note:

1) Groundwater elevation can vary by as much as 5 feet.
2) Water levels in the Columbia River can vary by as much as 10 feet due to seasonal and tidal influences.

Figure 2-2
Conceptual Hydrogeologic Model

EPA
REGION 10

033-RI-CO-1027
Frontier Hard Chrome
FOCUSED
FEASIBILITY STUDY

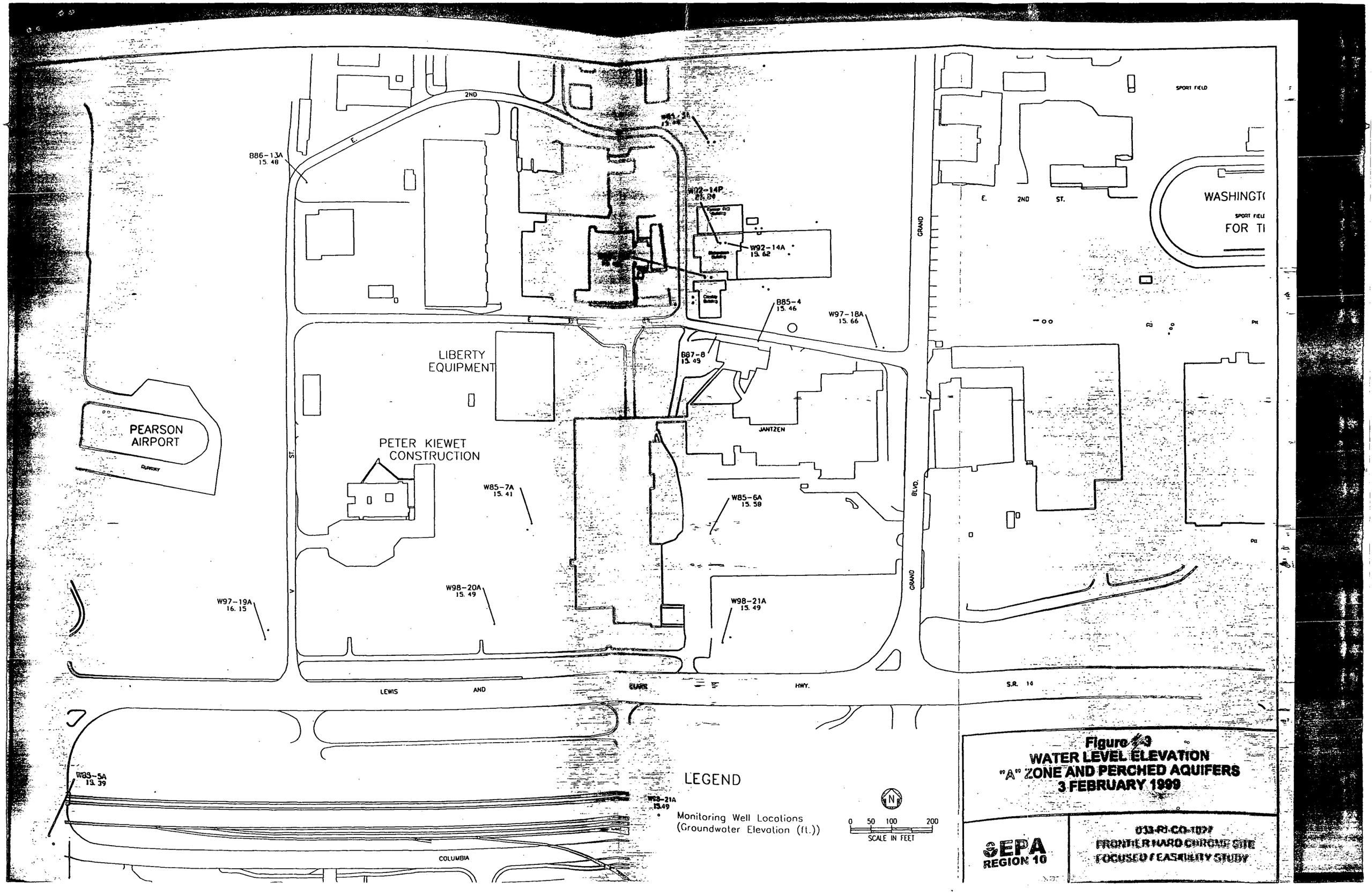


Figure 4-3
WATER LEVEL ELEVATION
"A" ZONE AND PERCHED AQUIFERS
3 FEBRUARY 1999

EPA REGION 10

013-RI-CO-1077
FRONTIER HARD CHROME SITE
FOCUSED FEASIBILITY STUDY

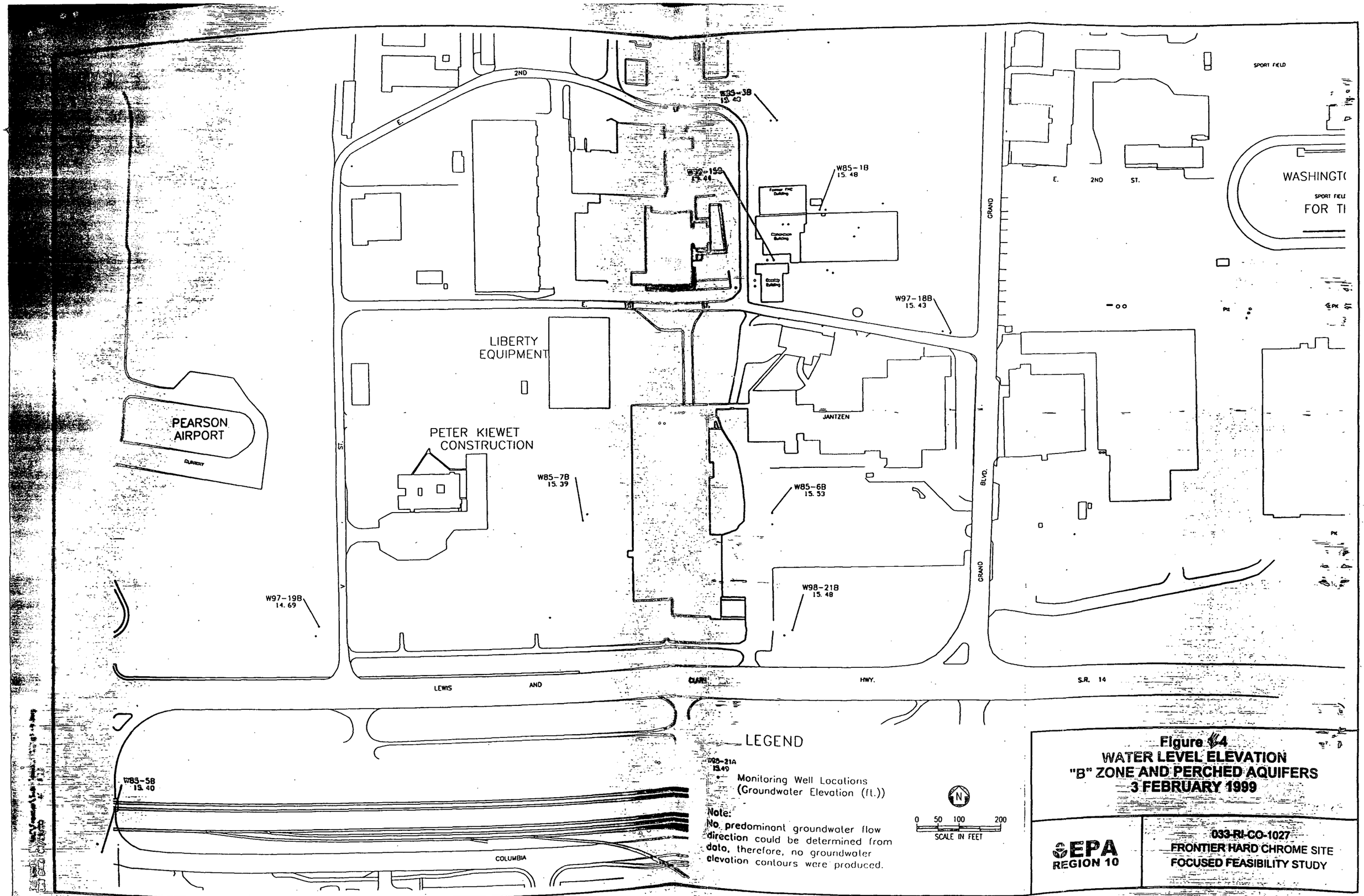
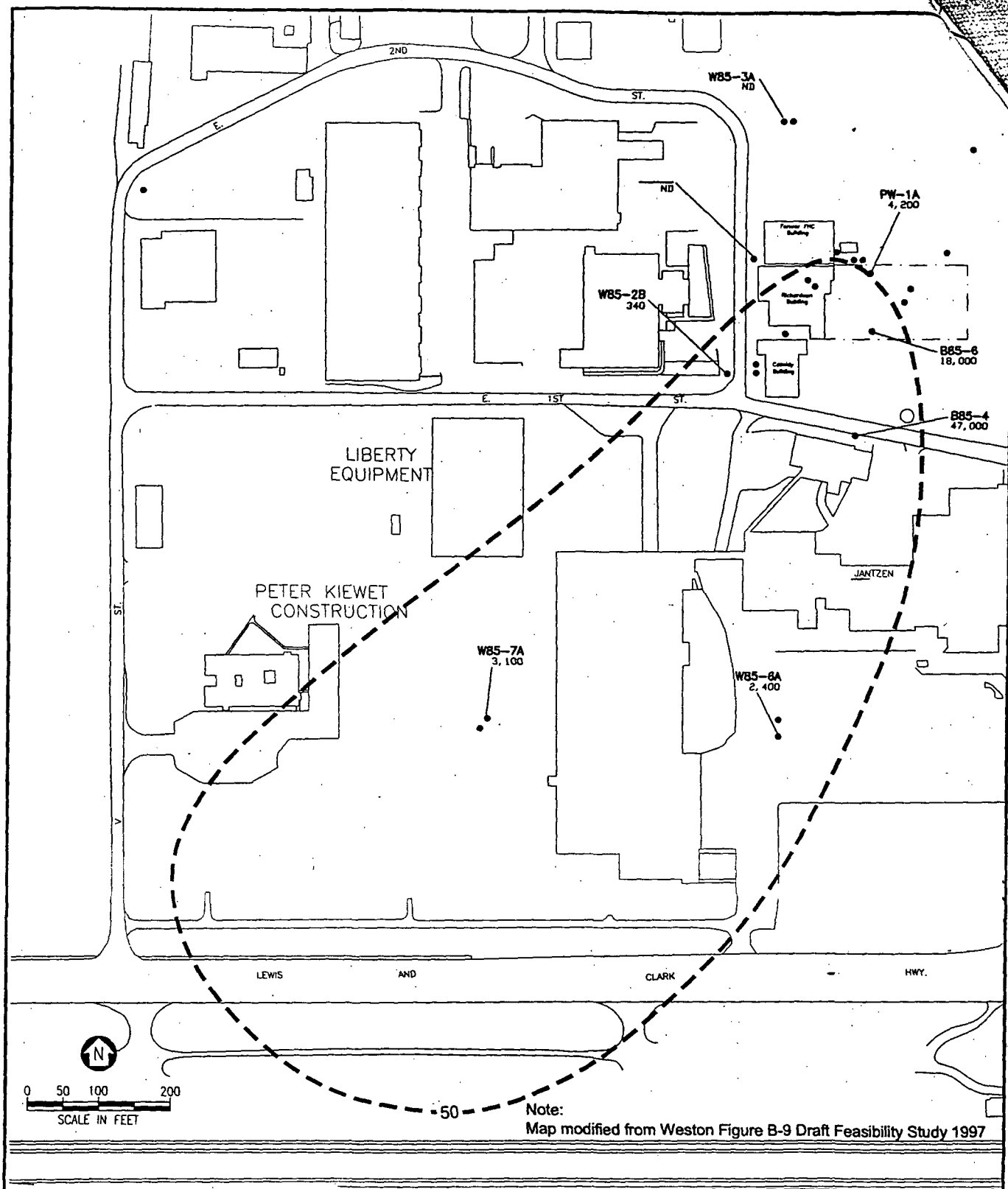


Figure 4
WATER LEVEL ELEVATION
"B" ZONE AND PERCHED AQUIFERS
3 FEBRUARY 1999

EPA REGION 10

033-RI-CO-1027
FRONTIER HARD CHROME SITE
FOCUSED FEASIBILITY STUDY



LEGEND

- Monitoring Well Location
  Chromium Concentration (ug/L)
- —50— Concentration Contour (ug/L)
- NS Not Sampled
- ND Nondetected
- 50 ug/L MTCA Method A Cleanup Level

Figure 5
Chromium Concentrations in Groundwater
January 1986

EPA REGION 10

033-RI-CO-1027
Frontier Hard Chrome Site
PROPOSED PLAN

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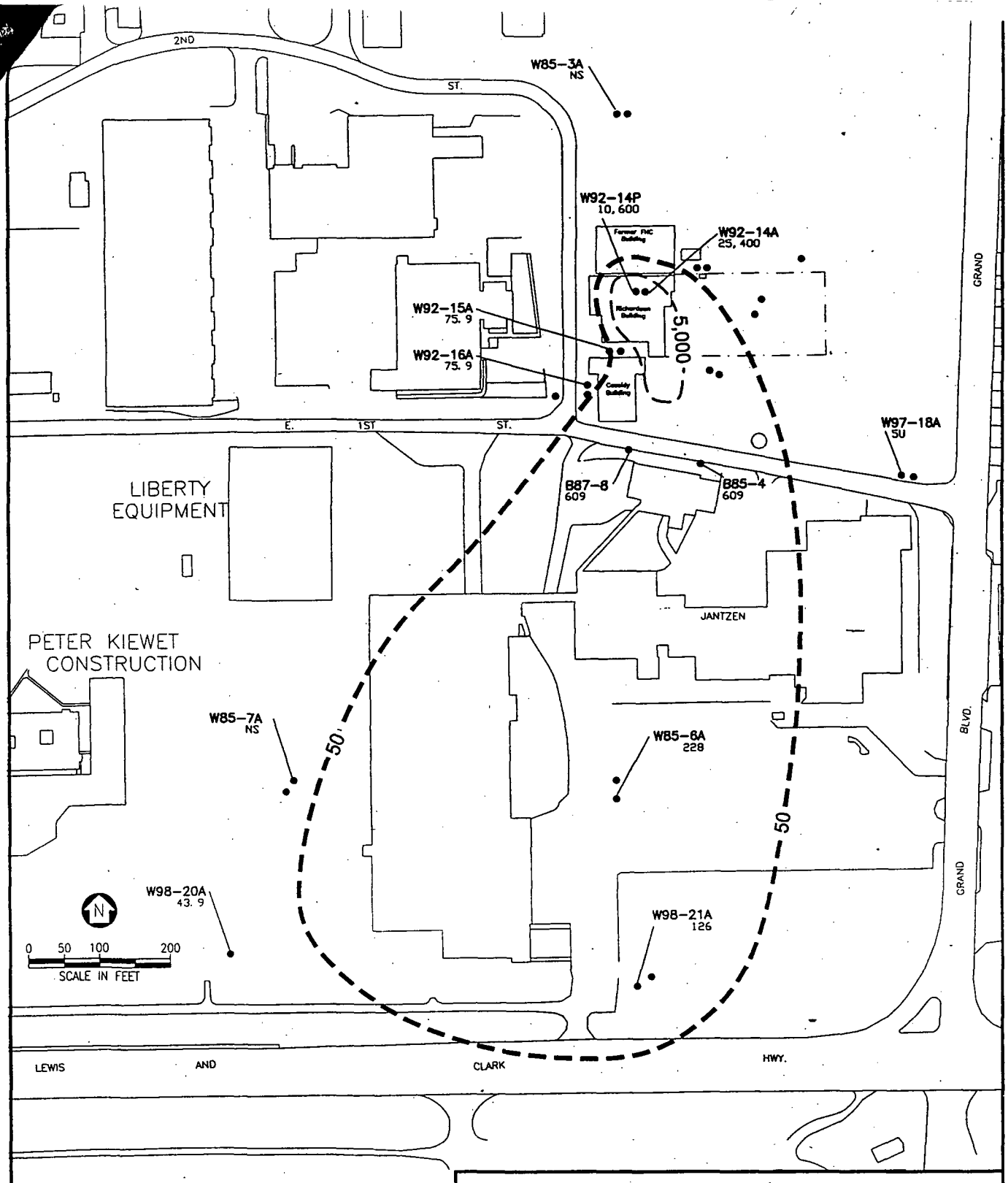

LEGEND

- • Monitoring Well Location
  Chromium Concentration (ug/L)
- — 50 — Concentration Contour (ug/L)
- NS Not Sampled
- ND Nondetected
- 50 ug/L MTCA Method A Cleanup Level

Figure 6
Chromium Concentrations in Groundwater
June 2000

EPA REGION 10

033-RI-CO-1027
Frontier Hard Chrome Site
PROPOSED PLAN

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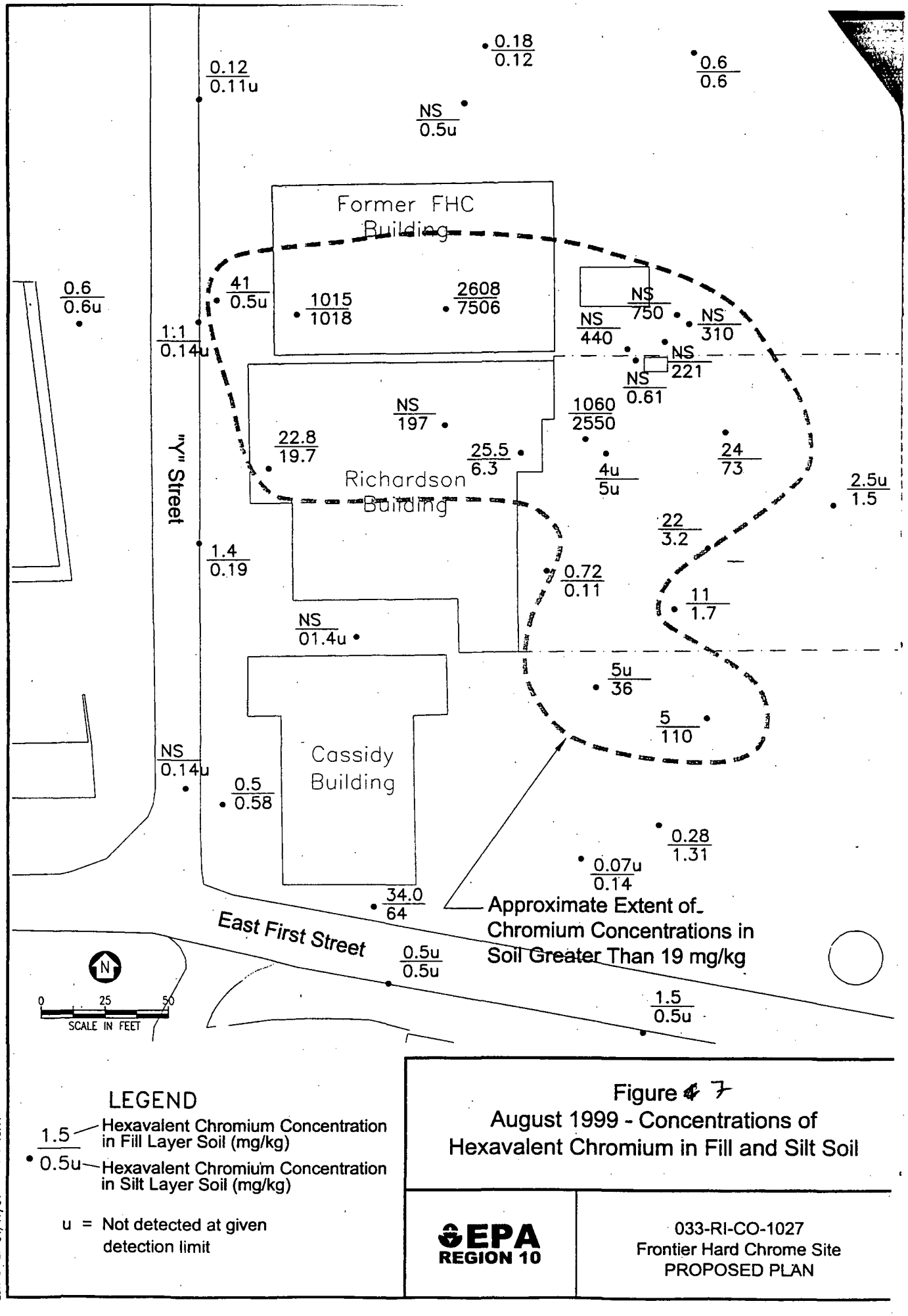

LEGEND

1.5 — Hexavalent Chromium Concentration in Fill Layer Soil (mg/kg)

• 0.5u — Hexavalent Chromium Concentration in Silt Layer Soil (mg/kg)

u = Not detected at given detection limit

Figure 7
August 1999 - Concentrations of
Hexavalent Chromium in Fill and Silt Soil

EPA REGION 10

033-RI-CO-1027
Frontier Hard Chrome Site
PROPOSED PLAN

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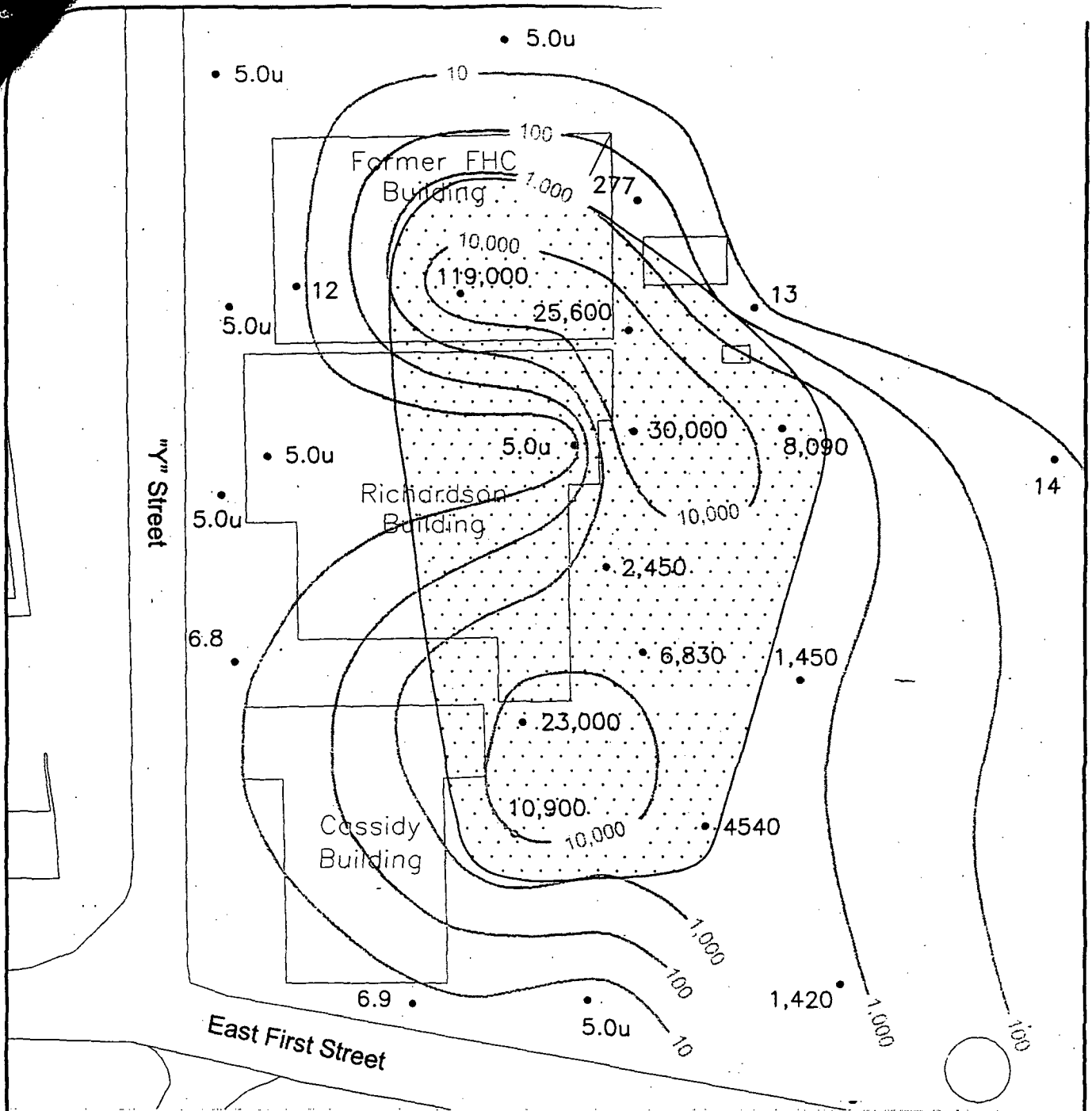

LEGEND

Chromium (total) concentration distribution in groundwater (August 1999)

Approximate area of "A" zone aquifer with chromium (total) concentrations (August 1999) greater than 5,000 ug/L

357 • Filtered Total Chromium Concentration (ug/L) (Direct-push sampling locations)

u = Not detected at given detection limit

N

0 25 50

SCALE IN FEET

Note:
Groundwater sample collected from temporary well points installed by direct-push method (Geoprobe™)

Figure ~~5~~ 9
Concentrations of Filtered Total Chromium in Groundwater August 1999

EPA REGION 10

033-RI-CO-1027
Frontier Hard Chrome Site
PROPOSED PLAN

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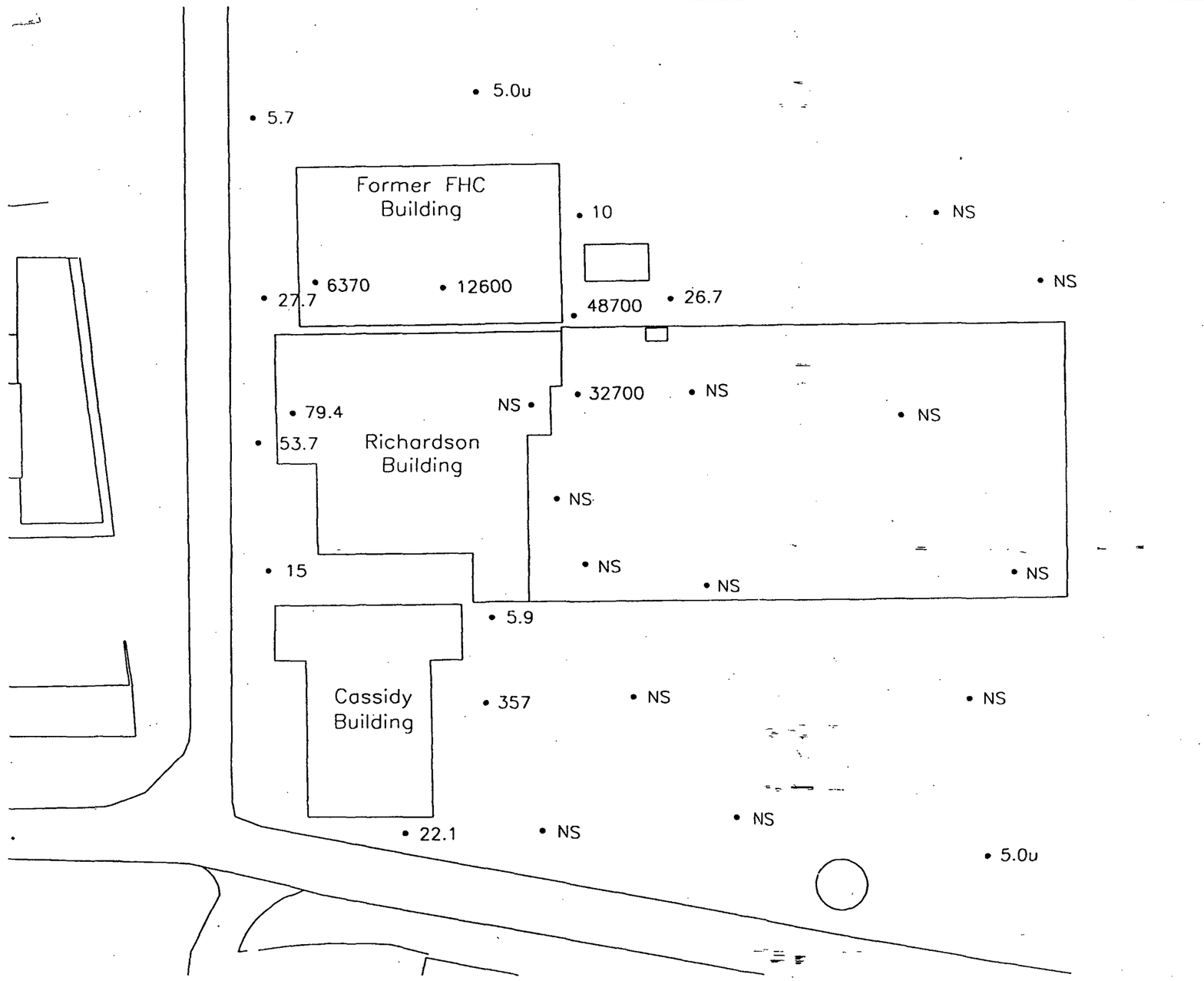

Note:
Groundwater sample collected from temporary well points installed by direct-push method (Geoprobe™)

LEGEND

357 • Filtered Total Chromium Concentration (ug/L) (Direct-push sampling locations)

NS = No Sample

u = Not detected at given detection limit

N

0 25 50
SCALE IN FEET

Figure 9
AUGUST 1999 - CONCENTRATIONS OF FILTERED TOTAL CHROMIUM IN PERCHED ZONE GROUNDWATER

EPA REGION 10

033-RI-CO-1027
FRONTIER HARD CHROME SITE
FOCUSED FEASIBILITY STUDY

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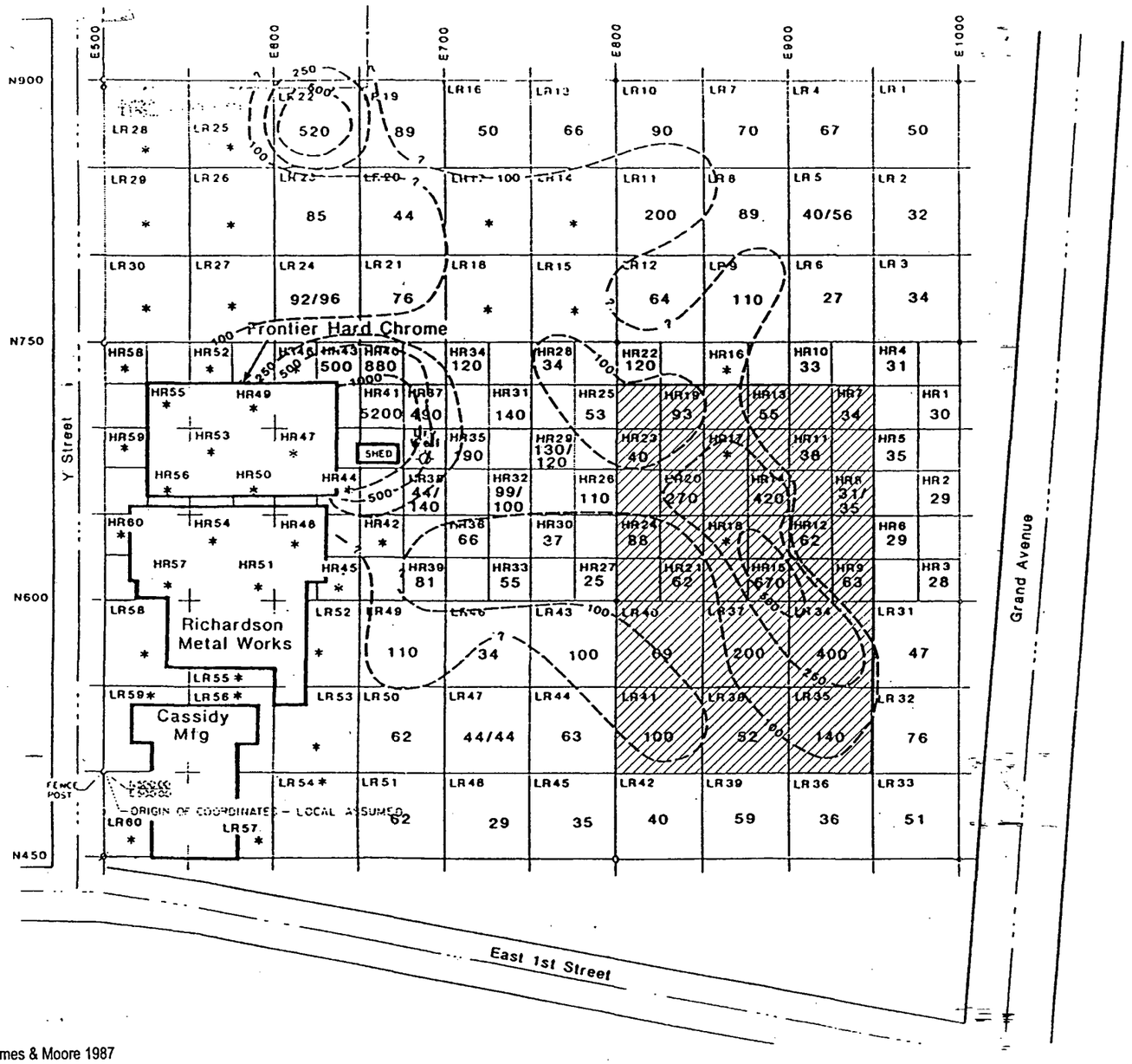

Source: Dames & Moore 1987

EXPLANATION

- Inferred Concentration Contour (mg/kg)
- 520 — Chromium in PPM (mg/kg) Dry Weight Basis
- HR — High Resolution Sample Grid Block 25' by 25' Square
- LR — Low Resolution Sample Grid Block 50' by 50' Square
- High Resolution Sample Grid Block Not Included in Sampling
- HR16 * — Grid Block Not Sampled
- Dry Well
- Building
- E50000 — Survey Coordinate

Notes:

1. Site and grid locations surveyed by Jim Weddle Associates, Inc.
2. Sec. 35, T2N, R1E, Willamette Meridian, Vancouver, Clark Co., Washington.
3. Sample Analyses of upper 1-foot from shallow soil borings S-7, S-8, S-9, S-10 considered in placing contour intervals.

Area Where Ecology Conducted Surface Soil Removal Action

N

0 50 100

Approximate Scale in Feet

Figure 10
Total Chromium Concentrations in Surface Soil

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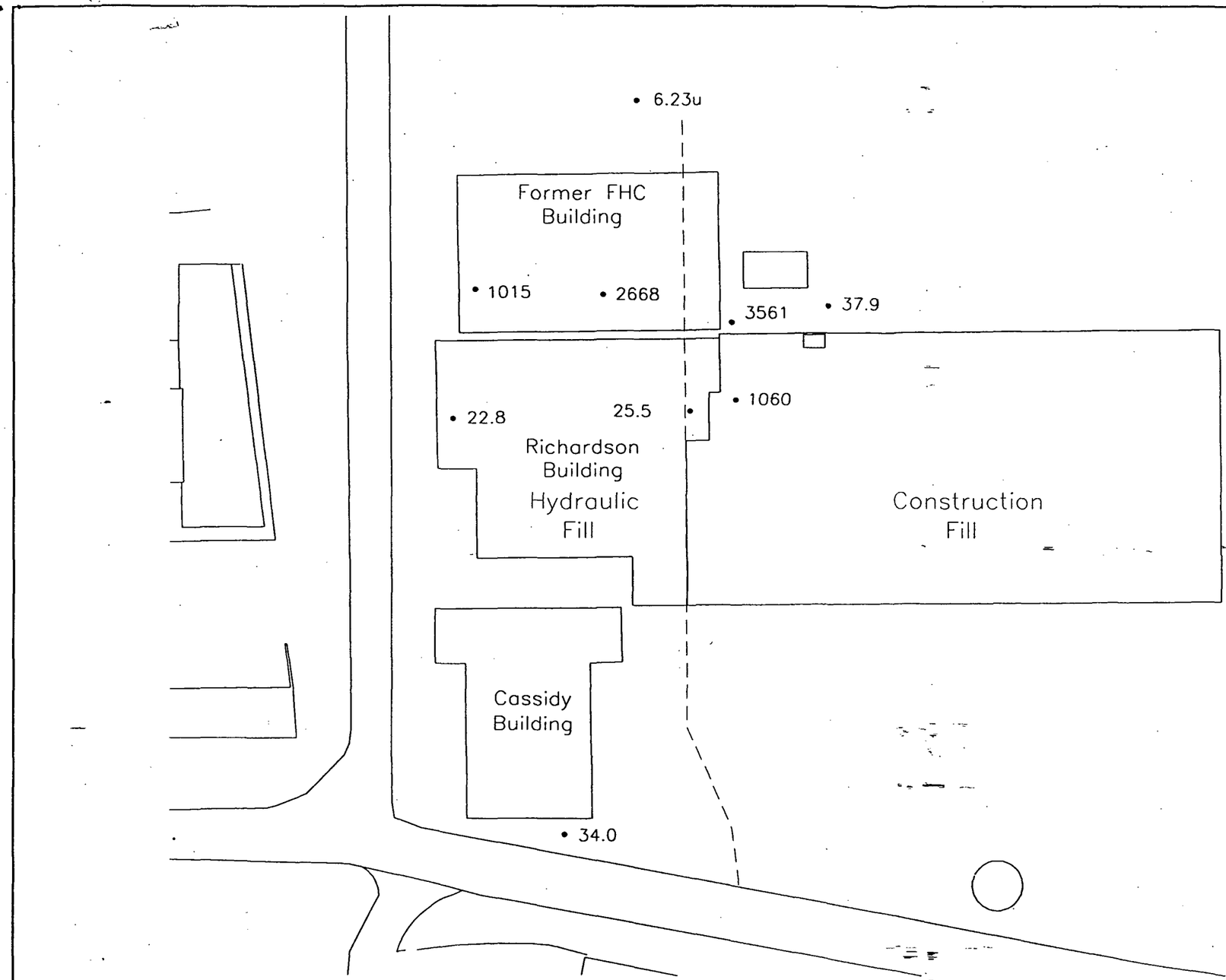

Figure 1-8
AUGUST 1999 - CONCENTRATIONS OF HEXAVALENT CHROMIUM IN FILL SOIL

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FRONTIER HARD CHROME SITE
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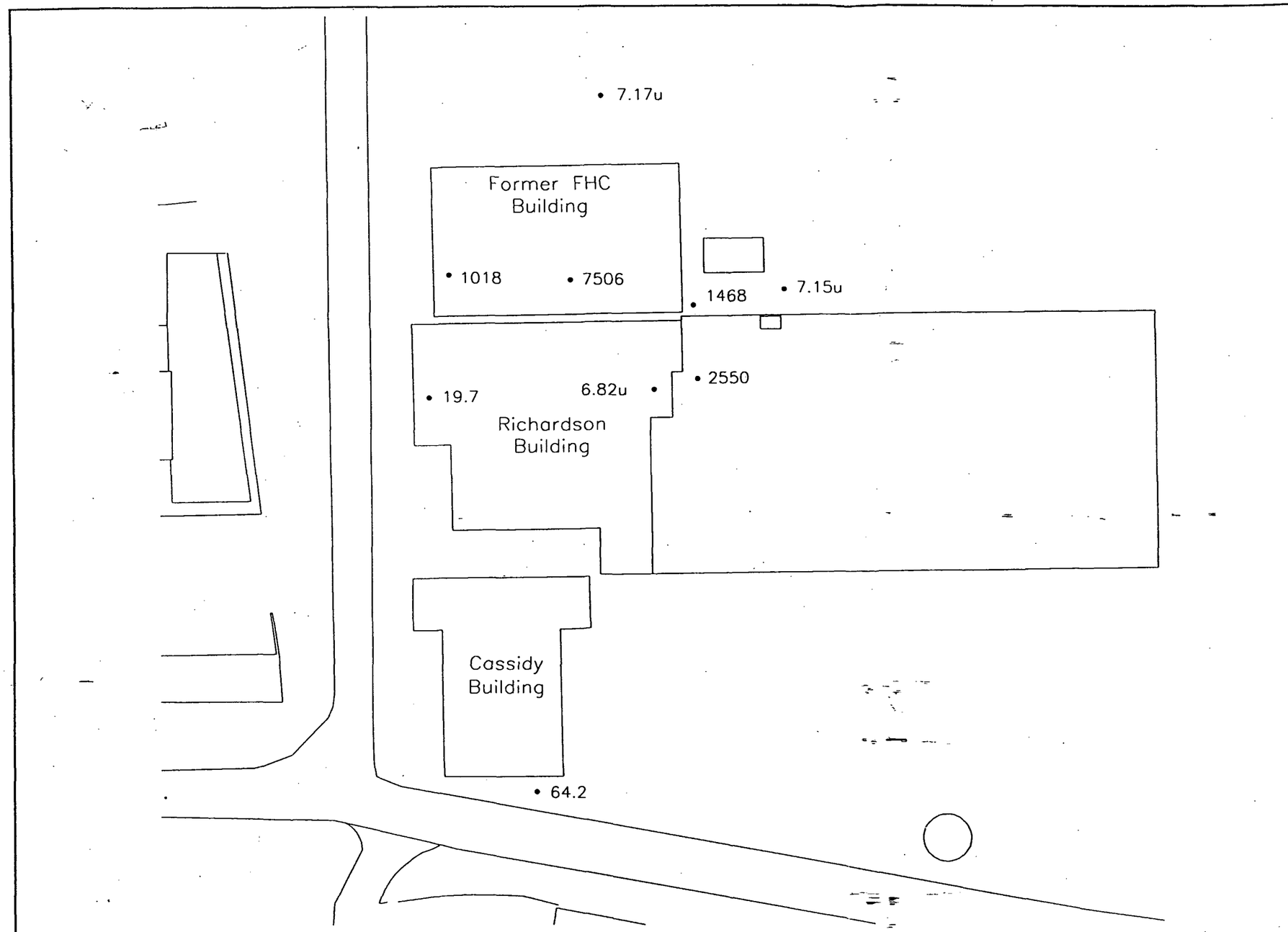

LEGEND

34.1 • Hexavalent Chromium Concentration (mg/kg)

N

0 25 50
SCALE IN FEET

Figure 1-9
AUGUST 1999 - CONCENTRATIONS OF HEXAVALENT CHROMIUM IN SILT LAYER SOIL

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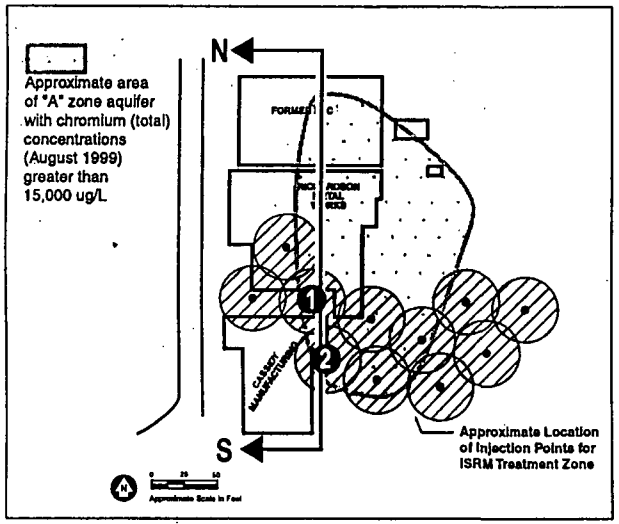

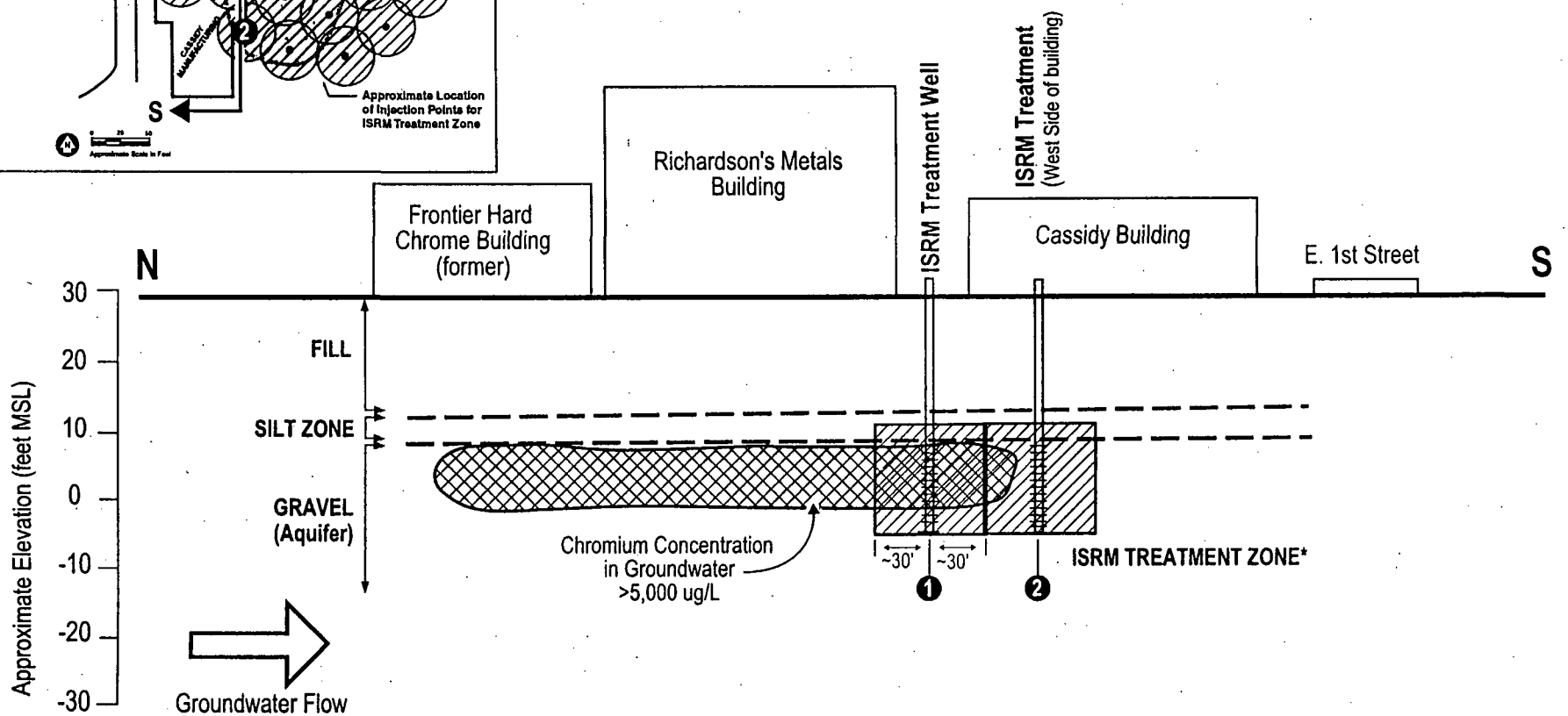

*Treatment zone could be installed using large diameter auger

1" = 50' horizontal
Vertical exaggeration 2:1

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Figure 3
Groundwater Alternative - ISRM Treatment Barrier

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PROPOSED PLAN

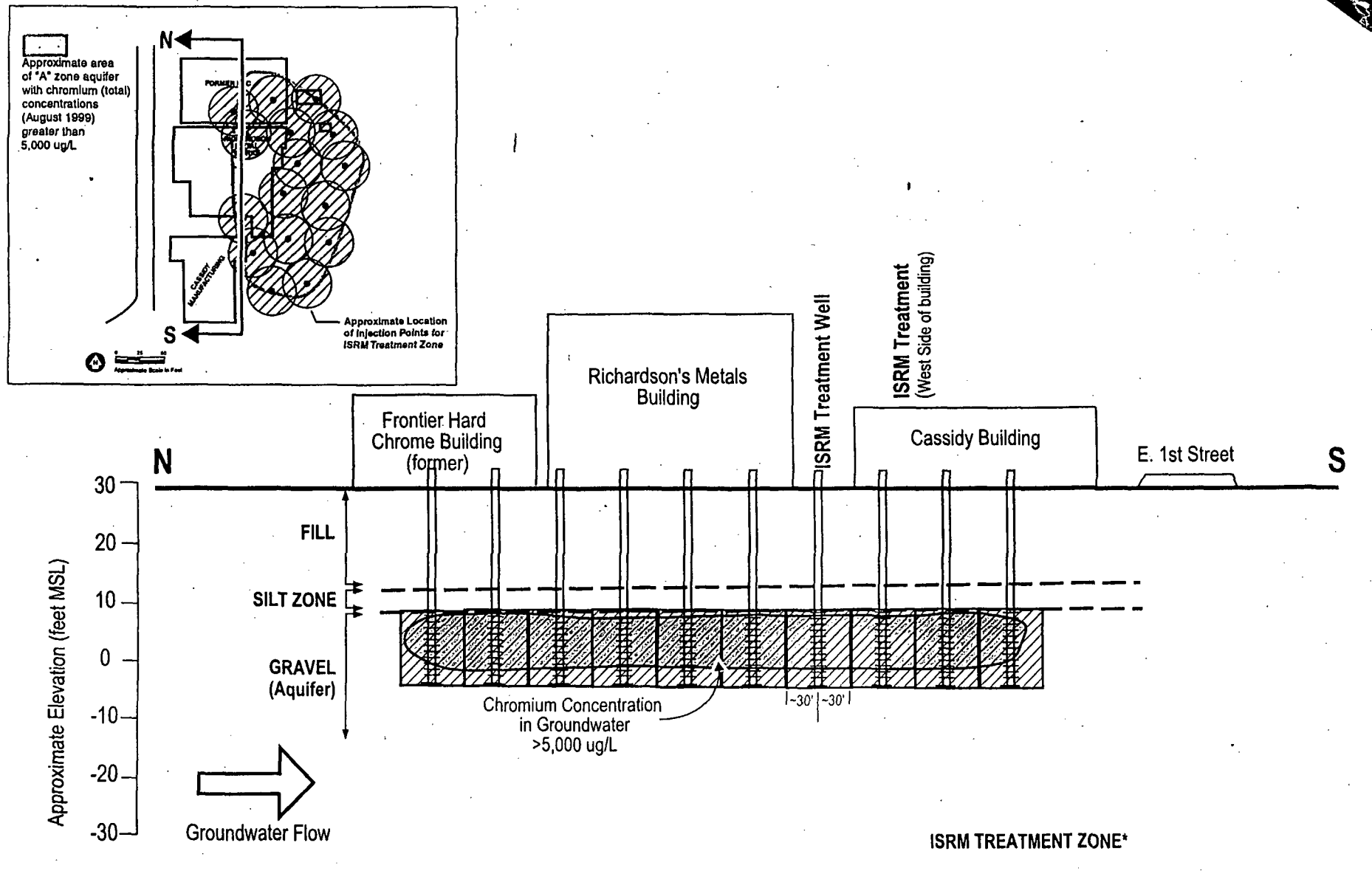

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Figure 14
Groundwater Alternative - ISRM Source Immobilization

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PROPOSED PLAN

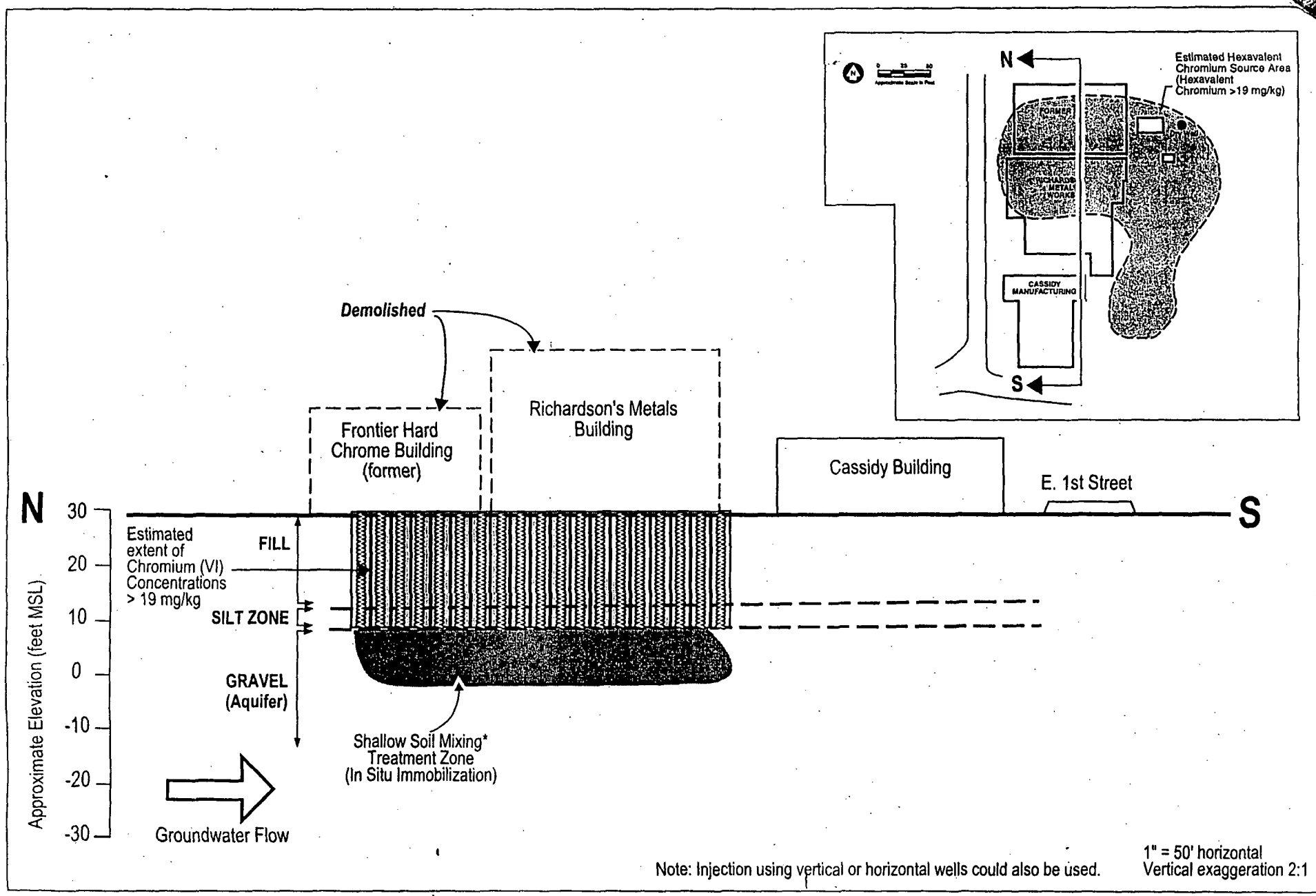

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Figure 8 5
Soil Alternative - Shallow Soil Mixing (In Situ Immobilization)

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Frontier Hard Chrome
PROPOSED PLAN

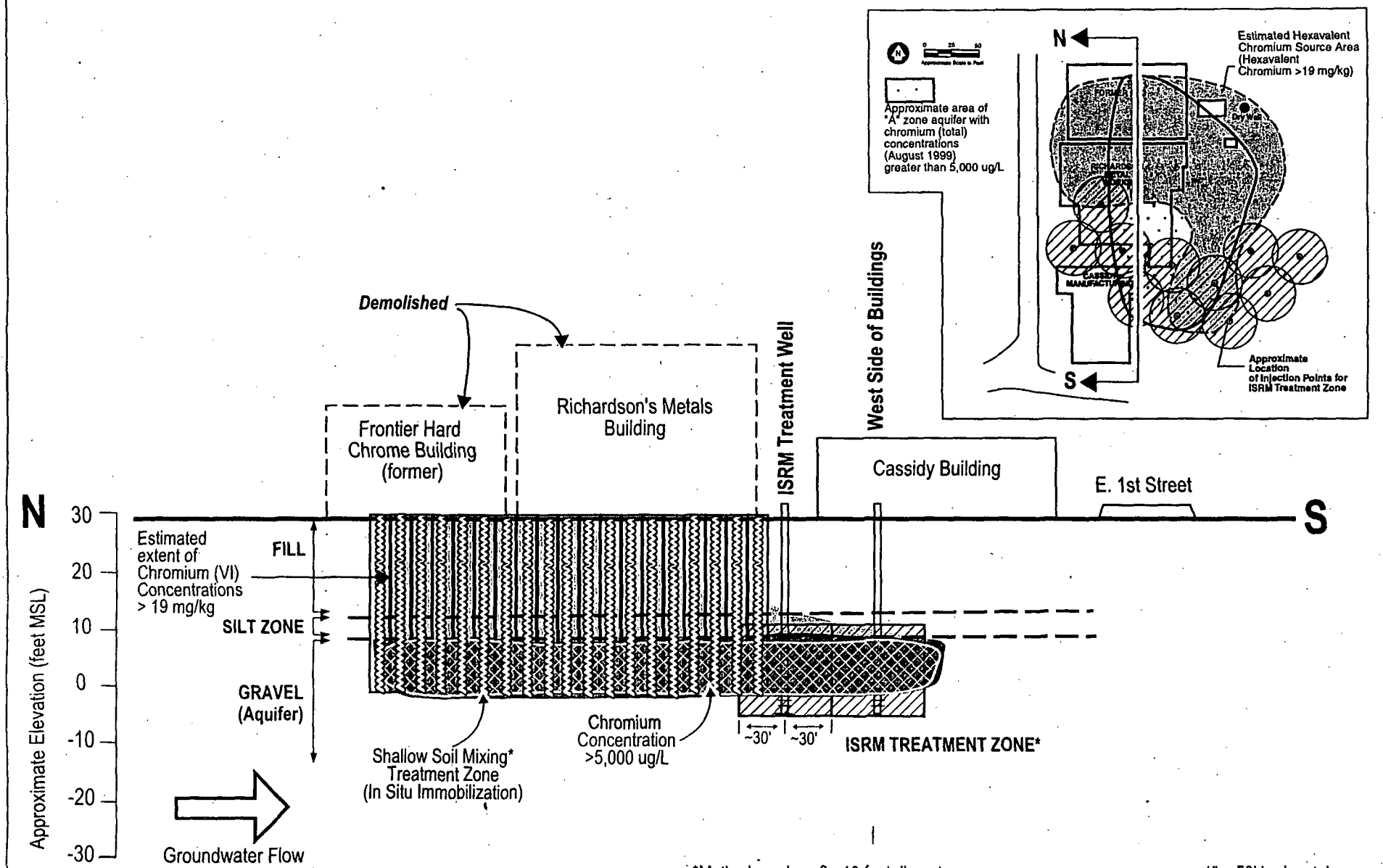

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Figure 6
Preferred Alternative - Soil and Groundwater
Selected Remedy

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Frontier Hard Chrome
PROPOSED PLAN